NEW SOLAR DEVELOPMENT MODELS FOR WEST MARIN: "COMMUNITY SOLAR" AND THE "SOLAR SAFETY NET"

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JUNE 2008

Three Reports funded by the
Marin Community Foundation

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New Solar Development Models for West Marin

Project Overview

Pathfinder Communications, the Solar Economy Institute, Presidio School of Management, Weinberg & Associates and NorCal Solar have collaborated to build upon the work initiated by the Stinson Beach Solar Committee to analyze potential new models to expand solar energy opportunities in West Marin. Marion Weber, a local philanthropist, both inspired and supported with seed money the early steps of this project. The analysis reviews multiple models of community-focused approaches to solar photovoltaic (PV) systems development, suggesting follow-up legislative and policy work at the state and county level of governance. This project was designed to run in parallel with Marin County's investigation of 'Community Choice Aggregation" (CCA). It also incorporates the concept of a "Solar Safety Net" (SSN) as developed by the Solar Economy Institute, which could be an initial step toward development of broader "Community Solar" (CS) programs throughout Marin County.

The SSN represents the Third Stage in solar energy development, integrating grid-tied advances with new inverter technologies to create a micro-grid in times of blackouts and grid failure. Community Solar can take many forms, but the focus in this project is two models: (1) larger solar PV generation facilities supported by "virtual" or "off-site" net metering; or (2) networked SSN installations that could create a regional micro-grid.

This public education, networking and technical/policy analysis project consists of three separate reports:

- **Part I:** The first report examines different models of CS, which is first defined and then examined for near-term viability given the context of rural West Marin's socioeconomic needs and cultural bias. In addition, this project tracked and actively shared information on solar technology, financing options and design considerations for community centers and school, fire and water districts in Point Reyes Station, Bolinas, Stinson Beach, Muir Beach and the San Geronimo Valley. A status report on high-profile solar systems in each of these communities is included in Appendix A of this first report in an effort to foster further community-based energy planning to lower carbon emissions while creating local employment opportunities.
- **Part II:** The second report examines a radical new model of solar energy development that represents the Third Stage of the solar energy movement. The SSN addressed the emergency preparedness needs of West Marin, but also represents a model with national implications and sets the stage for integrating solar into disaster preparedness programs that could be funded by the Federal Emergency Management Agency.
- **Part III:** Both CS and the SSN models are then analyzed within the context of Marin County's energy use profile, the proposed CCA program for Marin County, and the emergence of smart micro-grids.

The goals of this three-part project include: (1) learn and share information among West Marin communities pursuing radically different approaches to solar energy development in order to document successful strategies that can be then applied throughout Marin County and California under existing laws and regulations; (2) examine CS models employed elsewhere and figure out if they could be adapted to work in West Marin under a CCA and/or the status quo California Public Utility Commission (CPUC) regulations; (3) begin the analysis of a new model for solar energy development – the SSN -- that may open up financial support for solar-powered emergency back-up systems from the Federal Emergency Management Administration (FEMA) and other public and private sources of funding.

This last goal is particularly noteworthy, given the lengthy power outages that occurred throughout California in January 2008. The goal of the SSN analysis is to specify the technology and policy impediments to developing solar-based emergency power systems. This preliminary analysis will review how a SSN might work at the individual residence level, the neighborhood level, and at the level of a community center or fire station or other centrally located facility where citizens gather during power outage or other disasters. (Note: A neighborhood SSN then crosses over to become a new form of CS.)

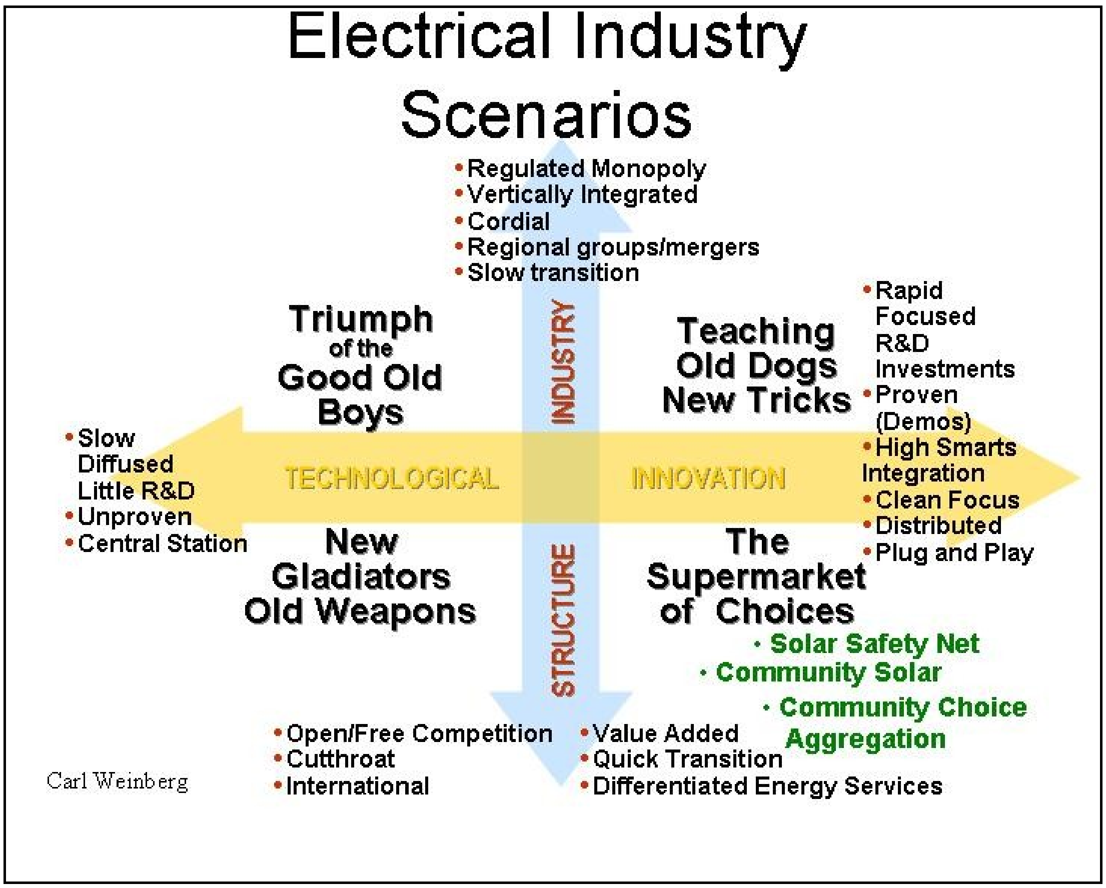
This project was designed to explore new models of solar energy development particularly suited to West Marin, but with broad applications throughout the county, state and country. Peter Asmus of Pathfinder Communications, manager of this research effort, is the prime author of Part I. Since existing technology allows the CS model to move forward immediately, the focus is on regulatory issues and recent legislation that chips away at PUC Code 218B2, a regulation that is the centerpiece of today's relationship between distribution utility and customer.

Part II is the result of research performed by four students at the Presidio School of Management -- Brett Bollinger, Adam Cornelius, Barbara Maco and Anthony Radspieler, Jr. -- for a sustainable products and services class taught by Tyrone Cashman of the Solar Economy Institute of Mill Valley. Jan McFarland, former executive director of the California Solar Energy Industries Association, took part in the early conceptualization work on the SSN; Adam Cornelius was an invaluable assistant in pulling this entire report together for final publication once his sustainable products and services class ended.

Part III is largely written by Pathfinder Communications and is based on discussions with Tim Rosenfeld, director of the Marin Energy Management Team, Jim McCray of Infotility, a firm conducting a smart grid solar R&D project in Marin County, and Carl Weinberg, former R&D manager of renewable energy sources for Pacific Gas& Electric (PG&E). Weinberg also reviewed all three reports and has included some of his infamous slides in Part I and Part III, including Figure 1 on the next page.

This figure is meant to depict that the electric utility industry is at a cross roads. The concept of competition was introduced in the early 1990's. De-regulation (some people might say "re-regulation"), was not uniformly accepted by all the states. So the electric industry finds itself today operating under a variety of regulatory regimes. More recently, national security and global climate change concerns have started to impose new design criteria, favoring more distributed and smaller and cleaner sources of power. In Figure 1, these dynamics are captured by illustrating two main axes. One spans *technology* and *innovation*. Do we stick with the old or do we introduce new technologies? The other axis spans the *completely regulated* all the way up to the *totally competitive*. Four possible futures are depicted. If you want cleaner generation you move to the right. If you want all regulation -- or complete market competition -- you move up or down. It is not clear just where the electric utility industry will move. But we as a society clearly must develop new models and move to the right.

Figure 1.



This three-part research and analysis project is designed to help move Marin County to the right, toward innovation and choice. It is designed fill gaps in the planning, structuring and financing of new models of solar energy development that are gaining community support throughout West Marin, but which are frustrated by existing state regulations. A top priority of the research and analysis phase of this project is to bring greater social equity to the solar market by allowing those consumers without fiscal resources or on-site solar availability to join the Third Stage of the solar energy revolution. The main thrust of networking activities in West Marin was to provide a forum for activists, businesses, government and community organizers to address the obstacles and opportunities for community cooperation in development of new renewable resources. In the event that the CCA does not move forward in 2008, this project still provides useful information about how various forms of CS and a SSN might be structured under the status quo relationship with PG&E.

Primary Project Findings and Results

- Each public agency building in West Marin targeted for conversion to solar power did indeed make the decision to go solar during the 12-month period of this project. These systems on community centers, fire stations, schools and water district facilities each employed a variety of companies, technologies and financing approaches to serve as compelling examples for other communities looking to green local public agency buildings. In one case, the intervention by Pathfinder Communications salvaged a 58 kW solar PV system that would not have been installed absent this MCF funded networking assistance.
- The key obstacle to CS is CPUC code 218B2, a fundamental underpinning of current utility policy regarding the "sharing" of energy generation. Therefore, the prime focus of the CS white paper is reviewing existing programs in other states and at public power entities, legislative precedents in California and new opportunities afforded by Community Choice Aggregation.
- The key obstacle to the SSN is long-standing anti-islanding bias among utilities due to employee safety concerns. Limitations of current storage technologies are also an issue.
- The most radical concept examined in this project – the SSN – was actually designed and installed during the course of this project at the Dance Palace in Point Reyes Station.
- The flurry of activity modifying California's net metering program reveal widespread interest in moving beyond single meter solar systems limited to meeting only on-site demand for power. This shifting policy landscape could provide an opening for both CS and the SSN to be debated within legislative and regulatory arenas in California and throughout the country.
- By coincidence, a pilot project focused on managing distributed solar PV systems installed at public agencies within Marin County and funded by the federal Department of Energy provides a strategic opportunity to link the concepts of CS and SSN to the growing interest in smart micro-grids.
- Among the chief obstacles to both CS and the SSN is cultural and shaped by language. Longstanding rules and codes carry weight, and past worries about public safety and the sanctity of past utility-customer relationships are formidable barriers.
- Advances in new technologies and analogies with the evolution of the Internet and telecommunication utilities suggest that the energy industry is on the verge of a major shift that will increasingly favor local, distributed and clean power generation sources.

Part I. Community Solar: Setting the Context

Solar photovoltaics (PV), small semi-conductors that generate electricity directly from sunlight, are the fastest growing power source in the world. By the end of this year, a total of 10 gigawatts (GW) of solar power will be up and running, generating clean electricity while also boosting reliability, local economic development and national security.[1]

There is no doubt that solar PV technology is undergoing a worldwide boom. Growing at a pace of 30 to 50 percent every year, solar energy is still just a drop in the bucket, generating less than one half of one percent of the world's total electricity.[2]

The prime obstacle to widespread deployment of solar PV has been cost. Thanks to forward-looking public policies enacted in other countries and more recently at the state level here in the US, solar technology costs have been cut in half over the past few decades. But the demand for solar PV has recently skyrocketed. Due to silicon shortages and corresponding lags in production, prices crept upwards over the last few years. In 2007, prices began to fall again and are expected to drop further by the end of 2008.

The solar PV industry has been focusing on innovations to reduce the cost of solar PV, recently cutting consumption of expensive silicon in the manufacturing process while increasing the efficiency of the conversion of sunlight into electricity. SunPower Corporation, which focuses on large commercial scale projects, has pledged to cut current costs in half by 2012, which will bring down costs to 12 to 18 cents per kWh, making solar PV competitive with peak wholesale and retail power rates.[3]

Despite the promise of solar energy, inconsistent and short-sighted government public policy threatens the widespread adoption of a source of energy that consistently ranks as the top choice of consumers. A prime reason why 80 percent of US solar PV installations are occurring in California is the State Legislature passed SB 1 in 2006, which created the California Solar Initiative (CSI) program. Under this long-term policy commitment to solar PV, California ratepayers will invest $3.2 billion over 11 years to add 3,000 MW of solar energy technologies to its grid by 2016, the year that optimists claim solar PV may no longer need major public subsidies.

One way to further lower the costs and boost participation in solar PV technologies is to design community-based programs that achieve economy of scale and reach markets that have yet to tap solar energy in a big way.

Marin County, as well as other communities in the San Francisco Bay Area, the Central Valley and in the Los Angeles Area, is currently investigating "Community Choice Aggregation" (CCA), a legal term that refers to a new way for cities and counties to

[1] Dick Swanson and Julie Blunden, *Solar Photovoltaics: History and Trends,* SunPower Corporation Power Point presentation to Pacific Gas & Electric, December 14, 2007.

[2] www.solarbuzz.com/FastFactsIndustry.htm

[3] "SunPower Signs Solar American Initiative Agreement with U.S. Department of Energy," SunPower Corporation press release, Sept. 17, 2007.

purchase electricity created by the passage of AB 117 by the California Legislature in 2002. Under this law, local governments can now represent constituents-at-large by choosing their power supply portfolio and setting rates to support that portfolio. Before this law was passed, the only way for a local government to have a say in where its power (and those of the residents and businesses residing within its boundaries) came from was to become a municipal utility. The CCA process provides an easier way to change the content of the power supply – by a vote of each local government -- without taking on the burden of managing the power lines, collecting bills, and the divisive politics involved with the typically highly contested (and expensive) municipalization process.

Under the proposed business plan for Marin County's CCA, the ultimate goal is to obtain 100 percent of the supply from renewable energy sources[4]. (Votes by each city and the County Board of Supervisors to approve this all-renewable energy supply portfolio will occur in the summer and fall of 2008.) This all green energy plan would cut Marin's overall total greenhouse gas emissions by 15 to 17 percent during the first year of implementation

Studies financed by Marin County show that it could get the vast majority of its total power requirements (200 of 240 MW) from solar PV systems located within the County's boundaries. But the cost would be prohibitive. Since the sentiment of this environmentally conscious community is to focus on local, indigenous renewable energy supplies, this report explores new models of solar energy development that would reduce costs and expand applications for solar energy, while opening the door to other creative solutions to energy at the local and community level.

[4] Navigant Consulting, *Option 2 Analysis: 100% Renewable Supply Goal,* Marin Community Choice Aggregation Project – Local Government Task Force Update, December 6th, 2007.

Putting Community First

What is "community solar?" The term means different things to different people. While the high-profile community institution solar projects described in Appendix A might seem to fall in this category, they each are akin to a commercial scale solar project providing power to a single meter under traditional utility regulations.

At present, the current hotspot for CS is the Pacific Northwest, where a legacy of public power has infused energy policy in this region with a sense of sharing resources for the greater good. According to advocates of community renewable energy development there, community solar is "less defined by the size of a single installation than by the cumulative benefits that go beyond any one private business or citizen." Examples of CS offered by the www.nwcommunityenergy.org website include the following:

- A cluster of installations where solar energy provides exceptional value;
- A cooperative is created as part of green power program within the operating framework of a municipal utility, a public utility district or rural coop;
- Solar arrays installed on public or non-profit group's building that serves the community and is funded through a specific green power tariff.

Also known as "Solar Shares," the community solar models being analyzed for West Marin do not fit neatly into any of the above referenced project descriptions, though it could include aspects of each of the above descriptions. **When used in the context of this report and the proposed CCA, CS refers to the ability of multiple users – often lacking the proper on-site solar resource or fiscal capacity or building ownership rights – to purchase a portion of their electricity from a solar facility that may be located off-site.** As explained in the white paper entitled *Solar Shares Business Model*, this model could greatly expand emerging markets for solar energy.[5]

> *The solar shares business model provides utility-scale, multi-megwatt (MW) photovoltaic (PV) systems the ability to distribute energy values across multiple utility customer classes, while capturing demand reduction at the site of the PV system, as well as valuing the Renewable Energy Credits (RECs). Net-metering in California opened up a new grid-tied market for PV in the 1990s. The potential exists to again increase the electricity market share for PV with offsite net-metering, or wheeling, of the electricity produced from PV systems.*

This report goes on to note that the current list of potential solar customers that are frozen out of the current booming solar market includes the following:

- Renters
- Condominium owners
- Commercial companies that lease rather than own their buildings
- Shaded rooftops or rooftops not oriented properly for solar gain.

[5] Joseph McCabe and Jon Bertolino, *Solar Shares Business Model*, white paper for the American Solar Energy Society conference in 2007.

- Aging rooftops
- Rooftops that require structural modifications to support the PV system
- Customers contemplating a move.

In essence, the terms CS or "Solar Shares" refers to the fact that multiple users can draw from a single solar PV array, or a series of arrays on different buildings but operated as a single system, supplying clean electricity to community institutions or residents that lacked good solar exposure. Under this CS model, participants, in essence, purchase shares of the total output from solar systems without necessarily paying the upfront costs or dealing with technical installation challenges.

To date, only a handful of CS projects have been developed in the nation. The most noteworthy projects have already been constructed in the Pacific Northwest in the City of Ellensburg, Washington, Ashland, Oregon and on Washington's San Juan Islands. In each of these three cases, the systems were developed by a municipal utility or a rural cooperative. But CS projects have also been developed on Martha's Vineyard in Massachusetts and on Block Island, Rhode Island. And the Sacramento Municipal Utility District (SMUD) launched a "SolarShare" program in 2007 as well.

The concept of "community wind," which appears to be more advanced than the notion of CS both here in the US as well as in Europe, connotes direct ownership of renewable energy resources, often through the Limited Liability Corporation (LLC) model. In Minnesota and Iowa, for example, farmers own shares of a single commercial scale wind turbine through this model, thereby benefiting from not only the power generated, but direct ownership of the asset. This report will also briefly touch upon how this model might be applied to solar resource opportunities in West Marin.

Growing interest in the concept of a "smart micro-grid" powered by solar PV and other distributed generation technologies represents an even more robust form of CS, and this model of solar energy development is discussed more thoroughly in Part III of this research project. It is possible to merge concepts of CS, SSN and a smart micro-grid, which would offer not only shared solar energy resources, but the ability to reduce energy use through "demand response" techniques and other ways of reducing consumption of utility grid power.

Community Solar and West Marin

According to Don Smith, the most ardent supporter of CS in West Marin, this model makes inherent sense for Marin County, especially in light of ongoing deliberations about the CCA. "Placing large solar arrays at optimum locations around the County is simply much more efficient than having little 'behind-the-meter' arrays on individual rooftops as is required under the current net metering rules," said Smith, who has been working on solar development proposals for the Bolinas water and fire districts for the past few years. He continued, "First, there is efficiency of scale in design, construction and monitoring costs. Second, there is increased power output per unit installed because the arrays can be placed on the sunniest sites and at the optimum geometrical orientation."

Smith concluded his comments on the role a CCA could play in developing solar power in West Marin with this plea:

> *"It has been very frustrating for me as a community solar advocate to be mired in regulations that unnecessarily complicate and impede the implementation of this crucial energy source. It's time to move forward. How can we get CCA and Solar Shares model underway in Marin?"*

The beauty of the "Solar Shares" or CS model is that it empowers all customers to gain the energy value of PV without having to locate the system onsite. Economies of scale can be captured – which lowers overall costs – making solar energy more affordable for all, and thereby contributing to Marin County's goal to support more local distributed renewable energy supply.

At present, two key obstacles face CS in Marin County because it is served by an investor-owned utility such as Pacific Gas & Electric (PG&E). The first is the on-site net metering requirements that preclude sharing any generation across different meters. The second is the current CSI program itself, which restricts eligible solar PV projects to solely meeting on-site electricity demand. This second obstacle would require a new law since this restriction was "hard-wired" into CPUC regulations.

From the CPUC's perspective, most CS programs chisel away at the sanctity of CPUC code 218B2 (http://www.leginfo.ca.gov/cgi-bin/displaycode?section=puc&group=00001-01000&file=201-248). In the words of Nick Chaset, an analyst at the energy resources branch of the CPUC, this code has been around for a long, long time "and is fundamental to the way our utility system works today." This rule, in essence, allows an electricity generator to share its output with two meters on the same site, but once a third meter enters the picture, the generator becomes an Energy Service Provider (ESP), subject to a range of regulatory requirements. The CPUC's suspension of "direct access" transactions (whereby customers contracted directly with non-utility providers) in the wake of the energy crisis of 2000-2001 has precluded new ESPs from generating new business in California, said Chaset.

A CS project would not only be illegal under present California law and utility practices because of its ESP status, but would fall into the category of an independent power producer and the generator would have to pay "wheeling" costs to move the electricity on its distribution grid from point of generation to point of consumption. They may also only be able to collect wholesale rates for electricity that can only be competitive if delivered at the higher retail rate. These PG&E charges would render such a project as uneconomic and would not capture the project's value to the grid and customers.

Yet another obstacle could by Rule 21, which governs interconnection agreements between generators and the distribution utility. A special Rule 21 process for solar PV projects mandates that if a solar PV project is over 1 MW, an interconnection study is required. If the host utility – in this case PG&E – finds that distribution upgrades are necessary to interconnect with the new generator, the project proponent is liable for these costs. Under the only current CS program operating in the state by SMUD, each solar PV project is 1 MW, but because these projects are developed within a municipal utility framework, they are not subject to these CPUC interconnection study requirements.

Recent Legislative Precedents and Activities

Despite these major barriers, at least two existing laws – one passed in 2002 (SB 1038) and the other in 2006 (AB 2573) – already allow solar power to be "wheeled" under a so-called "off-site net metering" arrangement from remote solar sites to end-use customers. SB 1038 authorized the PV-USA facility in Davis to provide electricity to a municipal landfill located miles away. AB 2573 allows Hetch Hetchy Water and Power to utilize PG&E's transmission and distribution lines to deliver electricity from remote solar PV systems to the City of San Francisco.

According to Jody London, a consultant to Marin County who recently authored the report *Increasing Renewable Energy Resources in the County of Marin,*[6] two other bills in the 2007 legislative session set important precedents to build the case for California to authorize the development of CS programs. AB 1969, passed in 2006, allows agricultural, municipal water and wastewater treatment facilities (as well as solar and small wind generators) to sell excess electricity from on-site generators at "Feed-In Tariff" rates adopted by the CPUC in December 2007. The projects are limited in size to 1.5 MW, which represents a very small traditional power plant, but a large solar PV array. The beauty of this program is that utilities purchase this renewable energy under "must take" 20-year contracts. The downside to the offer is that generators only paid the CPUC's "market referent" price, which the CPUC's Chaset estimated at 13 cents/kWh.

Chaset maintains this development model offers the best opportunity for Marin County residents to build community into the local power supply. "If the Marin County CCA owned these types of projects, they could sell shares in these local renewable energy facilities. Local citizens would actually have an equity share in a local renewable energy project," he suggested. He admitted this approach might not be as attractive as CS since these projects "do not offset one's own energy usage." In some ways, this approach is

[6] Jody London Consulting, *Increasing Renewable Energy Resources in the County of Marin,* Marin County Community Development Agency, November 11, 2007.

similar to ‘community wind” projects developed in the Midwest (see page 19). Because the CPUC’s market referent price may not be sufficient for solar PV projects at this point in time, wind projects and projects that create electricity from wastes may make a better match.

The other bill London referred to – SB 451 passed in 2007 – was vetoed due to a controversy over allocation of Renewable Energy Credits (RECs). But this law would also have allowed small-scale renewable generators to sell excess generation to investor-owned utilities at rates established by the CPUC.

Clearly, momentum is building to re-visit the current net metering policy structure, and allow residents, businesses and community institutions to play a larger role in generating electricity from renewable resources in excess of on-site power requirements. London made an important additional point. If Marin County did create a CCA and it became a co-owner of any renewable energy generation facility, the CCA and its partners could “do whatever they wanted with the excess energy.” Chaset echoed this same essential point.

Interestingly enough, Assemblymember Jared Huffman (D-San Rafael), whose district includes Marin County, has introduced AB 1920 in the 2008 legislative session. The bill would allow solar and small wind systems to be able to be compensated for excess electricity generated transmitted to their host utilities.[7] This legislation would also lift the current restriction of limiting one’s solar system to on-site electricity demand. However, the CSI rebate amount would be limited to only the capacity dedicated to serving on-site loads. The CPUC would determine the rate for this excess electricity – a figure between wholesale and retail rates– and the host investor-owned utilities would be able to count this renewable generation as contributions to meeting its RPS targets. Note that this law does *not* does not allow the solar PV system owner to share or sell this excess generation with other customers. However, it does open the market up to larger solar PV systems sending excess generation into the grid.

AB 1920 is one of a flurry of bills introduced in the 2008 legislative session to alter existing net metering rules. According to the CPUC, more than 40 bills were introduced to modify net metering at the start of the 2008 legislative session. Only a few viable measures are noteworthy in regards to the content of this report.

Perhaps the most important is AB 2466, which passed out of the Assembly Appropriations Committee unanimously on May 22nd. AB 2466 essentially allows local governments to engage in “off-site net metering,” also referred to as “virtual net metering.” The legislation would allow local agencies to generate electricity from renewable facilities at sites with no local demand, and then receive retail credit for this generation at other local agency sites where the power can be consumed. This bill provides yet another precedent for requiring host distribution utilities to transmit renewable energy from one site owned by the local government to another site owned by the same local government, without charging any distribution costs.

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[7] “Surplus Solar Power Legislation Introduced,” Environmental California press release, February 12, 2008.

SB 1714, which passed off the Senate floor on May 29th on a 25-15 vote, would require municipal utilities to offer "Feed-In Tariffs" for small renewable energy facilities operating under the same framework as established for investor-owned utilities under AB 1969.

AB 2863 (Leno) addressed the ESP status of "independent solar energy producers" – firms that lease a large solar PV systems to multiple end-users in an apartment building under a Power Purchase Agreement (PPA). The bill passed off the Assembly floor on the Consent Calendar in May. Sun Edison, MMA Renewables LLC and Solar Power Partners are new players in the energy marketplace, developing larger solar PV projects through Power Purchase Agreements (PPAs). These companies own the systems, but sell all of the output at fixed prices to building owners. Due to current regulatory uncertainty, separate subsidiaries are often created by these PPA firms to escape the regulatory obligations of being an "electrical corporation." This measure, too, reinforces trends chipping away at the traditional distinction between a utility, an ESP, and energy consumers. New models are popping up and the California Legislature is accommodating increasing demands for greater flexibility in allowing new actors to offer renewable energy services.

AB 1223 (Arambula), which was pending in the Senate as of the end of May, also moves in the same general policy direction of allowing more flexibility to owners of small renewable generation facilities. The legislation permits an agricultural user who relies upon solar or wind generation to aggregate multiple meters on properties under the same ownership and adjacent to the generator for the purpose of calculating net metering credits. Since West Marin features many agricultural operations – some of which already rely on solar and wind power – this measure could make these sorts of projects more viable. Still to be determined would be the advantage a CCA could offer on top of this new potential state law.

Existing Community Solar Programs

What follows is a brief summary of the three existing CS projects in the Pacific Northwest, a newly created CS program in Sacramento, and a possible community-based approach to solar energy being pushed in the City of Berkeley.

Solar Ashland: A collaborative effort between the city of Ashland, Oregon, Bonneville Environmental Foundation (BEF), Bonneville Power Administration (BPA), the State of Oregon and Avista Energy, this 38.9 kilowatt (kW) system was installed at four separate sites and was placed into service in August 2000.[8] This system is considered by some (mostly from Oregon) to be the nation's first CS project. Why? Surplus energy is sold to residents and businesses who sign up for the service. Unlike the Ellensburg CS project described below, the majority of upfront funding came from institutional sources.

All four installations featured DG-50 polycrystalline modules and Trace inverters. The four sites of installation were Southern Oregon University Library (10 kW), Oregon Shakespeare Festival Administration Building (10 kW), Ashland City Council Chambers (10 kW) and Ashland Police Station (15 kW). The electricity from these aggregated solar arrays is sold in the following ways:

- Ashland's municipal utility sells 10 kW to local subscribers employing "virtual" or "offsite" net metering;
- BPA sells 15 kW as "green power" to customers volunteering to pay premium green rates
- The remaining 5 kW is sold as generic power to the grid. BEF markets the RECs associated with these sales – also known as "green tags" -- to other customers wanting to offset their emissions, but which lacked adequate sites or resources to install an onsite renewable energy system.

In May 2007, Ashland expanded its "solar shares" program with the help of a $500,000 CREB. Under this roll-out program, city residents are eligible to purchase 375 shares @ $1,000 per share. Each share is financed by investing $8.50 monthly over the span of ten years. Per resident shares are capped at ten. The default purchaser of necessary shares to build the 66 kW system is the City of Ashland. But city officials are counting on local residents to participate. One reason for so much interest in the notion of CS in Ashland is geography. With a large mountain to the south, and many steep hillsides, the majority of people interested in solar energy had less than ideal access to sunshine.

Orcas Power and Light Company: Residents of the San Juan Islands became the first electric cooperative in Washington State to buy power directly from renewable resources in January 2005[9]. Four different solar arrays were installed on three of the islands by Orcas Power and Light Company (OPALCO). The purpose was to demonstrate the technology to local residents worried about dependence upon imported energy supplies. The local utility developed a program to link these distributed solar

[8] http://www.greentagusa.org/renewables/ashland.shtm.
[9] http://www.greentagusa.org/renewables/orcas.shtm.

arrays with other solar systems, creating, in effect, a multi-island renewable power grid. Solar arrays totaling 3.6 kW were installed at the OPALCO's Friday Harbor Office, Lopez Community Center, Westsound Marina and Windermere Realty Office.

Ellensburg Community Solar Electric Project: Billed by some as the first CS project in the nation, this 36-kW solar PV system was developed in partnership with BEF in November 2006.[10] The financial model designed by city staff allowed local individuals and businesses to help finance the upfront capital costs. In return, these customers receive credits on their electricity bills. Described as "virtual net metering," this model of solar development reduces the cost of solar energy due to economies of scale. Participation is simple: the writing of a check.

Here's how "virtual net metering" works in Ellensburg:

Solar contributors are entitled to a proportional share of the kWh output generated by the total array. The host municipal utility credits the customer's electric bill in proportion to the size of their financial investment. If this percentage adds up to 5 percent of total customer contributions to the project, the proportional dollar equivalent is deducted from the monthly utility bill. The "true-up" period occurs every three months. Total contributions during the three-month period are tallied and the corresponding percentage of total power generated is converted into dollars. A simple Excel spread sheet does the calculation. If contributors to this CS project move or want to opt out, they have the following options:

- Donate their contributed amount to a school, church or other community institution;
- Add the value of their community solar contribution to the sale of the house;
- Sell their contributed amount to someone else who is a utility customer;
- Sell the share back to the host utility at a depreciated value. Interestingly enough, the utility placed a cap on share buybacks of 10%. In other words, the utility will purchase back no more than 10% of the total shares in the project.

The Ellensburg municipal utility aggregates contributor support until 12 kW in demand is accumulated and then proceeds to develop the next CS system.

Sacramento Municipal Utility District: The first California CS program– called "SolarShare" – was launched by SMUD in September 2007.[11] Under this program, private developers able to take advantage of the federal tax incentives will build, own and operate systems of 1 MW in size. These developers enter into 20-year fixed price contracts to sell all of the output to SMUD, which then retails this power to participating customers.

[10] http://www.greentagusa.org/renewables/ellensburg.shtm
[11] "Soon Everyone Can Own a Piece of the Sun," Sacramento Municipal Utility District press release, September 20, 2007.

SMUD estimates that for less than $5 per month up to roughly $30 per month, most residential customers will be able to purchase between 10 and up to 50 percent of their power from these new solar facilities. SMUD, too, describes these purchases as coming from a “virtual” solar PV system. SMUD is marketing the program to customers that due to site problems, installation issues, up-front costs or status as renters, are unable to participate in the utility’s other solar programs. The end goal of SolarShare is to boost solar power production more than ten times its current level.[12] SMUD’s existing solar capacity ranks as among the most successful in the country. The municipal utility projects to add 16 MW of solar capacity annually over the next several years because of this new CS model.

Berkeley Community Financing Model: The City of Berkeley has proposed an innovative “Energy Assessment District” which could remedy many of the disincentives to install clean on-site distributed generation systems. It could also be considered a model for developing CS and neighborhood SSN systems. This model could be tremendously effective if expanded to include energy efficiency upgrades.

The Energy Assessment District proposed for Berkeley is modeled after existing Underground Utility Districts whereby a group of homeowners in a neighborhood work in coordination with the municipality on a plan to place utility distribution poles and wires underground. All property owners in the designated area vote on the proposal. If a sufficient majority votes in favor, the City works with the local utility to contract to have the infrastructure placed underground. The entire cost of the project is paid for with a non-tax exempt municipal bond. Homeowners repay the bond as an assessment on their property tax bills over a fixed period, typically 20 years or so. The assessment is officially in “second position” as a lien on the property – behind property tax and in front of the mortgage – giving excellent security and a corresponding low interest rate. A 20-year period fits well with the expected minimum lifetime of solar PV panels, too.

The City of Berkeley is creating a citywide voluntary Energy Assessment District. Under this new program, property owners (residential and commercial) could install solar PV systems and then pay for the cost as a 20-year assessment on their property tax bills. No property owner would pay an assessment unless they chose to include their property in the program. Those who do have work done on their property would pay only for the cost of their project (plus interest) and fees necessary to administer the program.

This approach solves many of the financial hurdles facing property owners. First, it significantly reduces the upfront cost to the property owner. Second, the total cost of the system may be less when compared to a traditional equity line or mortgage refinancing. This is because the well-secured bond should provide lower interest rates than is commercially available. (Another factor is that the City would require multiple projects to be aggregated in order to reduce construction costs.) Third, the tax assessment is transferable between owners. If the property is sold prior to the repayment of the

[12] Celia Lamb, “SMUD Seeks Bids For Shared Solar Generation,” *Sacramento Business Journal*, July 6, 2007.

assessment, the next owner would take over the assessment as part of their property tax bill.

Right now, this option is limited to charter cities such as Berkeley. Legislative changes would be necessary to adopt this model to municipalities located within Marin County as only San Rafael is the only charter city within the county. There is pending state legislation – AB 1709 (Hancock) -- to expand this program to “general law” cities. The program, known as “Berkeley First!,” has also been slow to get of the ground, so it is unclear at this point whether this is a model worth pursuing or not.

Community Wind Models from the Midwest

The concept of community wind is simple, revolving around local ownership and control. The key distinguishing feature is that local community members -- farmers, investors, businesses, schools, utilities, or other entities -- have a significant, direct financial stake in the project beyond just land lease payments and tax revenue. A recent report published in July 2007 defined "community wind" as featuring at least 51% local or in-state ownership[13]. Community wind projects can be any size, ranging from a single turbine to more than one hundred. Projects usually employ utility scale large wind turbines, yet typically serve local communities or consumers.

Today, community wind projects are being installed throughout the country and are in the planning stages in virtually every state currently witnessing wind power development.

The State of Iowa, for example, has approved a production tax credit specifically designed for community wind development that is expected to add 180 MW to the nation's existing inventory of 421 megawatts (MW) of community wind. This single state could hike total community wind capacity by 30 percent. And Minnesota -- the U.S. leader in community wind development -- has adopted a statewide goal of reaching 800 MW of community wind by 2010, a three-fold increase in the state's current community wind portfolio. This initiative will more than double the total community wind capacity installed nationwide.

These state initiatives attest that a growing percentage of new wind projects can indeed be locally owned. Community wind projects tend to be smaller, often utilizing the local distribution grid to supply power to the immediate area of the project. But they can also be integrated into regional strategies to bring clean and renewable electricity to major population centers. With increasing constraints on regional transmission systems, community wind will need to play a vital and growing role in meeting national and local energy demands in the near future.

Perhaps the best example of how "community wind" can benefit farmers is the story of Minwind Energy, which not only installed seven locally-owned wind projects in 2004, but linked these new clean electricity sources to a new ethanol production cooperative to help reduce pollution from automobiles. Minwind Energy began in 2002 when each original shareholder invested $500 in research and development to get the concept off the ground. Today, more than 11 community wind projects are up and running, each with its own board of shareholders. The Government Accountability Office has calculated that local ownership of these wind turbines increases local economic benefits by a factor of three.

Each community wind project is organized as a limited liability corporation (LLC). Among the stringent criteria for eligible shareholders in each LLC under the Minwind Energy model are the following: all shareholders had to be Minnesota residents; 85% of shareholders had to reside in rural communities; each shareholder was limited to a 15%

[13] Scott White, *Community Wind Incentives*, Kansas Energy Council, July 2007.

ownership share of each community wind project. Furthermore, each shareholder board for each Minwind Energy LLC had to be a group of unique citizens, in order to spread benefits throughout the rural community. Note that each of these shares in a community wind project is transferable among family members.

Luckily, each Minwind community wind project was able to access US Department of Agriculture grants of almost $180,000 each to help cover engineering, transmission, equipment and construction expenses. To date, Minwind Energy's projects are delivering enough clean electricity to power 3,800 homes.

For more information about "community wind," see the following websites: www.windustry.org and www.c-bed.org.

Conclusion: The Big Picture

Implementing the CS model in West Marin or any other community in California requires changes in legislation and/or regulations at the state level of governance. The flurry of bills introduced in the 2008 legislative session clearly demonstrates that momentum is building to adjust existing net metering requirements to accommodate growing interest in new models of solar energy development.

Tom Starrs, a national expert on net metering and community solar, agreed to be interviewed to provide a cultural analysis of why CS has been pioneered by public power entities and not investor-owned utilities. These quotes are presented here to clarify how existing CS projects differ from other solar projects. What follows are highlights from a May 2nd phone interview.

"Regulators impose obligations on investor-owned utilities for things they would otherwise not do. In contrast, public utility districts use the exemptions from state regulation to do even less, in some cases, and in other cases, to do even more. Among those entities doing more are SMUD, Austin Energy and the Los Angeles Department of Water and Power."

"In terms of innovation, state regulators tend to be late to the table."

"Interestingly enough, the proposal by Southern California Edison (SCE) to build 250 MW of distributed solar PV is an interesting new twist. Under the proposal, the entire customer base of SCE will pay for these new retail generation units that will be operated by SCE as if one huge power plant. With this approach, per customer costs are smaller than a typical CS approach, where the costs are often allocated according to voluntary premiums. With the SCE model, the delivery of the solar PV generation goes into the general mix of all of its customers. With "Community Solar," the energy is apportioned by the utility at the retail price, essentially working within the net metering framework."

"How is CS different than purchasing Renewable Energy Credits (RECs)? I am fully supportive of the REC market as I think customers should work to reduce their carbon footprints. However, with the purchase of RECs, there is often no direct tangible result for the consumer. Some purveyors of RECs won't even disclose which projects your voluntary premiums are supporting. With "Community Solar," the funding mechanism often makes non-economic solar projects viable. It may entail higher premiums, but the funds flow to a specific project usually in the same county or at least the same state. Another difference between a purchase of RECs and investment in CS is that with a REC purchase, you just offset the carbon. A premium invested in a CS project yields both the carbon offset and the actually delivery of energy."

"An investor-owned utility could implement the most recent SMUD "SolarShare" model; it would just require regulatory changes and approval. There are a lot of reasons not to go this route. For example, one issue is the subsidy of one customer class over the other. Utilities and regulators have a lot of rational arguments, but rational is not always right.

Today, many net metered solar PV systems are sub-optimal in terms of siting due to orientation, shade and other factors. With a CS approach, consumers could get more bang for the buck with better producing and larger-scale solar PV projects at optimal sites."

"The key for the future is the interplay between solar PV and a smarter grid. There has been a radical reduction in cost in power electronics and therefore power management has become much more cost effective. Right now, there is no smartness at the distribution level. It was too expensive to track information at that level. But there are new sensors and devices to collect this data and convey this information today. We could put a sensor at every transformer and distribution feeder, which could greatly enhance the management of distributed generation sources such as solar PV."

"In reaction to the energy crisis of 2000-2001, there was a retrenching on some of these issues as competition was viewed as evil in the wake of deregulation. This bias precluded many pro-consumer and pro-competition technologies. Sentiment is now moving back toward the middle with a healthy, more nuanced approach with a few utilities in the lead. If utilities can rate-base capital investments on smart grid technologies upgrades, we could be in good shape."

"Ultimately, village and community scale renewable micro-grids are the future. I like to use the computer analogy. We are moving toward a world where instead of large centralized mainframe computers, we rely upon remote interconnected lap tops. We could have entire subdivisions with a single master meter connected to the grid. These micro-grids could generate their own power and be entirely self-sufficient, and send power back and forth as a group or disconnect from the larger grid. The technology to do all of this is already here today."

Appendix A:

May 2008 Status Report
On West Marin Community Institution Solar Projects

Muir Beach: SunFirst! installed the first solar PV array on a community center in West Marin in 2005. Since the installer is based in Muir Beach, it donated most of the labor required to install a 2.4 kilowatt (kW) system on the roof of the Muir Beach Community Center. The project consisted of forty 60-watt models and a 2500 SMA inverter. A state rebate of approximately $9,000 was secured to pay for the majority of the hardware, so the out-of-pocket expense for the Muir Beach Community Special District was approximately $3,000. Unfortunately, the solar PV system has only covered about a third of the Community Center's energy usage due to shading in the afternoon from large trees to the West of the Community Center and the lack of energy conservation. "Pathway lights are often left on all night, and even during the day," observed Aran Collier, a SunFirst! veteran and Muir Beach resident. The solar PV panels have also not performed as well as expected.

Point Reyes Station: SunFirst! was chosen to be the installer for a 10 kW solar PV array on the Dance Palace, the community center of Point Reyes Station. Unlike the approach used in Muir Beach, the Dance Palace did entertain bids from a variety of vendors. The project benefited from a $25,000 grant from the County of Marin. County Supervisor Steve Kinsey announced this generous contribution from the County of Marin in the spring of 2007 and has implied similar grants may be forthcoming for other community center solar projects throughout Marin County. The Dance Palace also benefited from an unsolicited matching grant from local philanthropist Marion Weber of $10,000. With an expected rebate from the state, the majority of the equipment capital costs of $45,000 had been raised as of March 2008. Solar Depot, a large solar panel distributor with roots in West Marin, has also offered discounted equipment prices. Jerry Lunsford – a long-time solar advocate that has already installed numerous energy efficiency upgrades to the Dance Palace facilities – organized a multi-day public workshop in mid-May sponsored by the Solar Living Institute. A Solar Festival will take place at the Dance palace on July 13, 2008 to help educate local citizens about the benefits of solar energy.

Lunsford has noted there is room for 30 kW of solar PV on the rooftop of the Dance Palace. In the ideal world, he would love to install this much solar PV capacity so that the output could be shared by the nearby Fire Station and other local consumers in Point Reyes Station. That is why he endorses the concept of CS and has offered up the Dance Palace as a pilot project site. He also loved the idea of the SSN ("after all, we are a disaster relief site!") and integrated this concept into the system design for a 10 kW solar PV array installed at the Dance Palace in May-June 2008.

"The Solar Safety Net concept makes perfect sense," Jerry Lunsford, technical director at the Dance Palace, a community center and federal disaster relief center located in Point Reyes Station said. "We are very vulnerable in the rural areas of West Marin. Our electrical infrastructure is vulnerable to many possible failures. In the event of a catastrophic winter storm or earthquake, the Dance Palace could be without the basic needs of power, light and heat for many hours or days. Since this is a disaster relief site, this is far from the ideal situation. Having a small battery based backup system will allow us to meet the basic survival needs of our neighbors and the community for an extended period of time," he said. Since Lunsford lives nearby with an off-grid solar PV array as his prime power source, he is enamored by the possibility of installing the nation's first Solar Safety Net. At this point, it is unclear how PG&E feels about this novel development.

As described in more detail in Part II of this report, Lunsford's approach was to divide the 10 kW system into a AC/DC hybrid system featuring one 5 kW array connected to an AC grid-tied inverter and a second 5 kW solar PV array that goes through a sub-panel and a Sunnyboy Islander, which is then backed-up by a bank of Absorbed Glass Matt (AGM) lead acid batteries. (AGM batteries rely upon thicker lead than traditional batteries. They are also sealed, so there is no off-gassing or evaporation.) The load of essential services – lights, the office and refrigerator -- is directly connected to a sub-panel on the automatic transfer side of the inverter. The design is based on the SSN concept of only providing essential services at the community center during an extended grid power outage.

Bolinas: Of all the West Marin communities, Bolinas is the most active with large-scale solar projects linked to community assets. Four different projects involving community members and institutions are in the works. Each of these projects is described separately below.

Don Smith, a BPUD director, energy consultant and owner of his own residential solar PV array, has been working on the concept of CS longer than anyone else in West Marin. He has identified two sites that he thinks would be ideal for large centralized solar arrays that could serve multiple customers in Bolinas: BCPUD property up on the Mesa next to current wastewater treatment facilities; private property on a hill with good solar exposure and a willing landowner interested in building a solar facility to serve his a restaurant, bar and food store. After more than a year of research into the regulatory and financial challenges associated with "community solar," he switched gears and attempted to raise funds from private investors for solar PV projects installed on the rooftops of community institutions.

- *Bolinas Community Public Utility District*: Smith looked closely at the Power Purchase Agreement (PPA[14]) model, but he instead proceeded to secure federal

[14] Under the PPA model, private investors with "passive income"(i.e. rental properties) or large multi-national corporations with deep pockets (i.e. GE Capital) can underwrite solar systems on non-profit or public sector buildings, taking advantage of the federal and state solar tax credits. These owners lease the solar system. The host facility – such as a water, fire or school district – derives the benefit of locally-generated renewable energy at a fixed rate. In most deals, the starting price is just below local utility rates. Since most rates of private utilities – including PG&E – keep escalating, the public district's savings could grow larger with time, if structured appropriately. Under the best arrangements, ownership of the solar system reverts to the owners of the host building when all of the tax benefits have been fully maximized by

Clean Revenue Energy Bonds[15] for two BCPUD projects: a sewage treatment plant (66 kW); and a water treatment plant (27 kW). This interest free federal loan program penciled out better than the PPA deals. These projects are moving forward with San Rafael-based SPG Solar at a price of $7.75/watt, with state rebates covering roughly a third of the cost. By relying upon the CSI rebate to help pay off the principal over the first five years, the overall capital costs are expected to be paid off in 16 years. After that point in time, the electricity will be free over the life of the equipment. Smith commented the most onerous aspect of these solar projects has been the public bid process, which required the drafting of a document over 90 pages long.

- *Bolinas Fire Station and Medical Center:* Smith has also secured CREBs funding and Level 4 CSI rebates for the new Fire Station and Medical Clinic, which are each served by a single electricity meter and therefore can share the output of a single solar array. The installation contract was awarded to Pacific Green Energy in late May for a 22 kW system. David Kimball, director of the Bolinas Fire Public District (BFPD) and Phil Buchanan, another BFPD director, are now managing that project, in coordination with Smith.

- *Bolinas Community Center:* A new solar company based in Stinson Beach – Pacific Green Energy –initially proposed to develop an 11.6 kW solar PV system for the Bolinas Community Center (BCC). Since this is a new company created by two brothers with deep familial roots in the region, they have offered to donate the labor costs – an estimated value of $30,000 -- and only charge the Community Center for the capital costs of solar equipment. The BCC was not a public agency, so was not eligible for CREBs. The BCC was eligible to go the PPA route, but the project was too small to be attractive to firms offering PPAs. Like the Dance Palace project, Pacific Green Energy has also been offered a $10,000 matching grant from local philanthropist Marion Weber and has held community-based fundraising events at the Bolinas Community Center to raise funds from local residents. The total cost of the project is estimated to be $130,000. The Bolinas Community Center could serve as a site for a CS pilot project, linking the BCC and the People's Store to a shared common area serving two different meters. In fact, because both BBC and the People's Store are on the same property, the firm revised its proposal in early 2008 to expand the solar PV array on the BBC to 20 kW in order to serve both buildings, an early form of "community solar." Interest was expressed in the SSN concept, but the BBC had

the private investors.

[15] CREB's have been allocated on an annual basis by Congress beginning in 2005. Thanks to a free service provided by the County of Marin, more than $43 million of federal interest-free bonds have been reserved for solar projects for 22 different Marin County public agencies. Recipients of CREBs are allowed five years to install the renewable energy system. Since the smallest projects are given top priority in CREB awards, applications from West Marin have an excellent chance of being funded. The $31 million in CREB applications in 2007 represent roughly 12 percent of the *total* federal CREB funding for small projects nationwide! All told, the 88 different potential solar projects for local schools, fire and water districts will add up to 5.2 MW of solar PV, doubling Marin County's current total solar PV capacity.

just decided to seriously consider investing $4,000 into a used propane gas generator located literally next door.

- *Bolinas-Stinson Beach School District:* Tom Williard, one of two brothers who are principals of the Sustainergy Systems firm of Inverness, is managing this challenging solar project. Current plans call for two separate 20 kW systems since each school building on common property has individual electricity meters. Williard investigated the PPA model, but many PPA firms dropped out from the bidding process as they viewed small school district projects as inherently risky and unprofitable. (Some firms informed Williard that they had already met their quota of notoriously difficult school district projects.) Any solar project placed on the roof of a school building must be approved by the Department of the State Architect (DSA), a very time-consuming and burdensome process. A required DSA independent engineer review has found that one of the rooftops meets its structural integrity requirements, while the other does not. Thanks to some creative paper shuffling, Williard has been able to extend for another six months a CSI rebate installation date deadline. Early concerns about the viability of the CREBs because only one northern California firm – Stone & Youngberg – had successfully marketed them, have largely disappeared. A new company– Brandis-Tallman – sold CREBs for solar projects by public agencies in Sebastopol and has pledged to do the same for all water, fire and school districts in Bolinas.

Stinson Beach: Stinson Beach created a Solar Committee in 2005 over two years ago, which then launched the highly successful "Stinson Solar Sunday" event in February 2006, which drew over 300 people to the Stinson Beach Community Center (SBCC). But efforts to install solar PV on the SBCC stalled. On March 19th, 2008 the SBCC board chose Borrego Solar, a statewide family-owned business that has been operating in the Bay Area since 1980, to install a solar PV system on two of the three buildings that the SBCC owns at the corner of Belvedere and Highway One. (Marin Solar and Pacific Green Energy were the other two unsuccessful bidders.) Borrego Solar has made this contract the centerpiece of local solar PV promotion. If is offering any resident of Stinson Beach, as well as the rest of West Marin, a $500 discount to any resident choosing Borrego Solar that will then go towards underwriting the cost of the solar array at the SBCC and Fire Station #1.

The winning proposal calls for an 11.4 kW solar PV system to be installed on the roof of the main hall of the SBCC to power this building and the Chapel; an 8.4 kW system will be installed on the roof of Stinson Beach Fire House #1. Systems of that size should provide approximately 91 percent of the Fire Station's power needs and roughly 85 percent of the main hall of the SBCC and the adjacent Chapels demand for electricity. "We just felt it was time for the Community Center to step-up and reduce our environmental footprint as well protect ourselves from rising utility costs," said Toby Bisson, president of the SBCC Board. "We hope to set an example for the community, and inspire others to turn to solar and other forms of renewable energy," said Bisson. Due to the plethora of wealthy individuals residing in Stinson Beach, the community helps to self-finance the installation. 'Due to the generosity of this community, we were able to raise over $60,000 for the construction of Fire Station #2," noted Kenny Stevens, Stinson Beach Fire Chief. He expressed optimism that the community would help raise more than that to help pay of the new solar system. State rebates under the California Solar Initiative should cover almost a third of the costs and local philanthropist Marion Weber has also offered a $10,000 matching grant. Since the Fire Station just invested $9,000 into back-up emergency power generators, there was no interest in the Solar Safety Net concept. As of the end of May, $35,000 of the $100,000 necessary to construct the two solar PV arrays had been raised. (The expected CSI rebate is $37,000.)

Lagunitas School District/ San Geronimo Valley Community Center: A $150,000 state rebate for a 58 kW solar PV system was in serious jeopardy if the Lagunitas School District did not have a solar system in place by the end of last year. Upon hearing about this predicament, Pathfinder Communications put Dave Cort, general manager of the San Geronimo Valley Community Center (SGVCC) – which is a structure on school property of the Lagunitas School District -- in touch with Solar Power Partners (SPP), a new firm based in Mill Valley that specializes in the Power Purchase Agreement (PPA) financial model. Working in partnership with Borrego Solar (their contracted PV integrator), SPP was able to gain an installation date extension from PG&E just after the school district approved the solar project at a December 20th, 2007 meeting.

Due to the orientation and angle of rooftops -- and the delays that would have been encountered with an engineering review and approval by the Division of State of Architecture (DSA) -- SPP and Borrego went with a ground mounted system that will provide about 95 percent of the entire school districts electricity needs. Given the nature of when schools operate and therefore consume energy, the school district will be able to offset most of its annual electrical bill from PG&E by becoming a net producer of solar electricity sent to the grid during the peak summer hours. "Having a ground mounted system will also help make the solar system an educational tool for the children, since it will be more visible than a rooftop mounted solar array," said Todd Michaels, Director of Business Development for SPP.

Though Lagunitas is the only community institution in West Marin to go the route of the PPA, Michaels pointed to California Solar Initiative statistics compiled by the firm Suncentric that showed that more than 60 percent of non-residential installations of solar PV were financed with the PPA model in 2007. This trend continues to grow rapidly as state budgets are cut and consumer spending tightens. According to Michaels, PPAs were the main reason the California solar market grew so fast last year: "Like the car loan did for the auto industry and the calling plan did for cellular, the rise of the PPA model streamlined the market and makes solar projects feasible to a broader base."

According to Dave Cort, general manager of the SGVCC, the Lagunitas School District had received a federal grant of roughly $1 million to build a new gym. The original design of the building incorporated a number of green building practices since the community wanted the new structure to be as environmentally sustainable as possible. "All along, we associated solar energy with sustainability," acknowledged Cort. However, the first architectural rendering of the new super-green gym cost way too much money. On top of that, the rooftop's exposure to solar energy was less than ideal. "We are very happy that SPP came through because we would have never been able to pull this all together – a $350,000 investment -- without their financial help," said Cort.

Evergreen Solar was chosen as the PV panel manufacturer for two key reasons: they are the most environmentally superior solar PV panels because half as much energy is required to make each panel if compared to the industry average; they are one of the few solar panel products manufactured in the US. SPP worked with an international bank to construct its first 15 solar projects valued at $35 million. SPP entered the market in 2007 and by the end of 2008 expects to have over 40 projects completed across the US representing approximately 15 MW of distributed solar PV capacity.

PART II:

THE EVOLUTION OF SOLAR AND RATIONALE FOR THE "SOLAR SAFETY NET"

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Overview: This Historical Moment

The movement to replace carbon-fuel sources of electricity in the developed world with solar-renewable energy sources is about to accelerate. There are many reasons for this. Society is concerned with the need for climate change prevention, air pollution mitigation, and reducing dependency on foreign sources of fossil fuel. Consumers are concerned with protection against the likelihood of steeply rising electricity rates due to the coming political restrictions on CO_2 emissions. Utilities are concerned with the prevention of brown-outs and black-outs during the predicted increasingly high and long-lasting summer peaks in demand for more electricity.

An important segment of the larger solar-renewable movement is rooftop solar photovoltaics (PV.) This segment of the movement is now entering its Third Stage, and Marin County is at the forefront of this evolution.

The Three Stages

The First Stage of rooftop solar PV occurred in the 1970s and 1980s, when the technology was still very expensive but was less expensive than paying for utility grid power in remote sites. Homes and work installations that were a mile or two from the utility grid found that on-site solar PV with battery storage was more cost effective than extending the grid to their home, farm or business.

The Second Stage occurred in the 1990s and the early part of the 21st century as the cost of solar PV decreased while state and federal incentives for home and business PV installations increased. This Second Stage was the movement to grid-tied rooftop solar PV arrays, often with the added incentive of net metering programs, where utilities purchase excess power at retail rates. In this system, the utility grid functions essentially as the backup for the PV array, receiving excess power during the day and providing power during the night. The present regulatory environment throughout the country has been designed around this Second Stage, accommodating only single owner rooftop arrays — each behind a single electric meter — with the added requirement that the inverter stop providing power from the solar PV array whenever there is a grid failure.

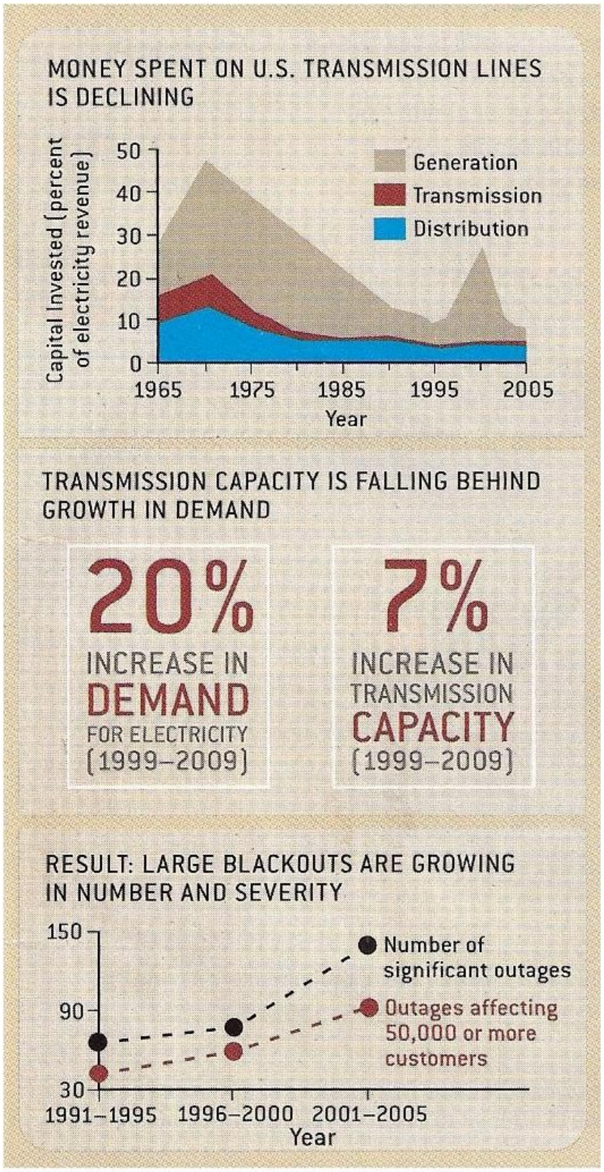
The following analysis explores what is likely to be the Third Stage of local power production by solar PV: the emergence of solar micro-grids that can come in the form of previously described Community Solar (CS) projects, or the more radical notion of a Solar Safety Net (SSN): a way to provide long-term power for critical needs to homes, businesses or neighborhoods during an emergency that involves grid failure.

The New Factors Shaping Solar Markets

The new factors that are driving the Third Stage of solar PV development are not just local, but national and global in scope.

Virtually all segments of American society now strongly support the expansion of cost-effective solar to address the need for climate protection and energy independence. As solar PV prices come down, limitations in the design of the built environment and its access to the solar resource begin to be the next barrier to the expansion of the use of solar. However, if the regulations and practices that grew out of, and are appropriate to, the Second Stage of solar PV deployment remain in common use, the shift to a more rapid deployment of solar wherever the appropriate resource is available in each local area, including West Marin, could be retarded. Expanding CS and SSN opportunities under the Third Stage will make maximum deployment possible throughout Marin County, the state, and the nation.

Figure 2. Demand Effects on the Grid[16]



As Figure 2 illustrates, the American electricity grid — originally designed during the rural electrification program of the Roosevelt era — is now out of date, both in its conceptualization as well as in its age and fragility. Compounding the original grid design flaws are increasing demands for electricity. As a result, there has been a steep rise in grid failures small and large since the mid-90s — sometimes with very large cascading effects. A recent study by the Electric Power Research Institute (EPRI) estimates that redesigning and rebuilding the utility grid will require more than a decade of steep costs:

"Technologically, the self-healing smart grid is no longer a distant dream. Finding the money to build it however is another matter…"

"The grid would be costly, though not prohibitively so given historical investments. EPRI estimates that testing and installation across the entire U.S. transmission and distribution system could run $13 billion a year for ten years — 65% more than the industry is currently investing annually."[17]

Two additional new factors render the electricity grid even more fragile: First, planners expect more severe weather effects from global climate change. The early impacts are already being felt throughout the world. Summers will be hotter, with longer and more intense heat waves, driving up air-conditioning use and with it summer peaks in energy demand. Hurricanes and tornadoes will be more powerful and more frequent on the coasts and in the Midwest. Heat-driven wildfires are already sweeping regions of the Western states. Destabilized rainfall patterns will cause greater floods and droughts. Winter snowstorms will, due to warming, frequently change to ice storms, which break electrical wires.

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[16] Amin, Massoud & Schewe, Phillip F., "Preventing Blackouts," *Scientific American*, May 2007, p 63.
[17] *Ibid*. p. 67.

Secondly, the geopolitical situation now includes a serious and continual risk of intentional sabotage of symbolic buildings and economically vital infrastructure. The agencies in charge of protecting the U.S. infrastructure know how few trained individuals would be necessary to cripple large segments of the electrical grid. This security threat may only grow with time.

As grid vulnerability increases, it becomes more obvious that one of the most serious design flaws of today’s electric grid system is that it is an all-or-nothing system. When the grid is functioning, customers can access enough power to meet any of their needs. When there is grid failure, customers have nothing: no refrigeration, no home heating, no lights, no security systems, no radio or TV, no cordless phones for land lines, no Internet or computer functionality. In a world that has evolved to be highly dependent on electrical energy in every aspect of life, this is serious business.

On the upside, an historical factor driving the Third Stage of solar PV development is the extraordinary rise of computing power. Vastly more sophisticated control systems for electricity production and distribution are now available. Computer systems are now available for monitoring output and input, sending signals both by wired and wireless communications to control remote stations and appliances, shaping the sine waves and adjusting frequencies of electric current, and increasing the efficiency both of production and consumption of electricity in numerous ways. All of these advances will enable the development of smart micro-grids with sophisticated automatic controls systems and redundant safety procedures for individuals, neighborhoods, and disaster relief centers — most likely in ways not yet even conceived of.

In the Third Stage of local solar PV production, many of the grid’s problems can be mitigated or solved. They can even be solved independently of vast new expenditures for grid upgrade and redesign. The Third Stage of local solar PV will begin to solve these problems from the neighborhoods up rather than from the central power plants down. The SSN is symbolic of this Third Stage.

What is a Solar Safety Net?

The SSN will be designed to provide adequate power during utility grid failure through reliable solar and backup power storage for critical emergency electricity loads. The SSN concept focuses on individual home and community-based solar PV systems that provide customers with reliable power for vital needs. The SSN can also promote long-term cost savings through efficient load reductions. The difference in a population with a small amount of power when the grid goes down versus no power for vital services is the difference between a population that can be part of the solution and a population that merely represents additional victims.

Ideally, a viable SSN service organization would guide customers through the complexities of the various key stakeholders involved in implementing renewable energy systems for disaster mitigation. The service could also provide guidance for funding, system selection, design, permitting, installation, and ongoing operation and maintenance.

The analysis that follows will look at the environmental conditions which make the SSN a valuable community asset, as well as examine its strengths, weaknesses, opportunities, and threats. It will cover the stakeholders involved in the various functions of a proposed SSN service and look at the features of both the existing prototype installed in Point Reyes Station in May-June 2008 as well as future concepts from the technical, policy, and funding perspectives. Finally, the SSN's potential profitability and sustainable return on investment (SROI) will be taken into consideration to determine the project's environmental and social sustainability, as well as its financial viability.

Situational Analysis

Along with the factors previously outlined that are fueling the Third Stage of local solar PV development, there are additional drivers behind the growing interest in all renewable energy sources, including a variety of solar energy technologies:

— Air pollution mitigation in the Central Valley;

— Consumer's protection against the likelihood of steeply-rising electricity rates, which rose nationally by more than 12% between 2006 and 2007.[18] As AB 32's mandates to reduce greenhouse gas emissions begin to be enforced in 2010, utilities in California could increase rates by as much as 13%;[19]

— Installation of large solar PV systems by large commercial customers and investor-owned utilities to comply with AB 32, California's climate change law or, in the case of utilities, to comply with California's Renewable Portfolio Standard (RPS).

The SSN will expand the usefulness of grid-tied solar PV systems to include providing locally distributed energy during periods of grid failure. The concept is a response to the challenges of global warming and presumed increases in natural disasters that may significantly influence the stability of the grid. "Over the 21st century, the frequency of extreme heat events for major cities in heavily air-conditioned California is projected to increase rapidly," claims one recent study. "Increases range from approximately double the present-day number of days for inland California cities (e.g. Sacramento and Fresno), to up to four times for previously temperate coastal cities implying that present day "heat wave" conditions may dominate summer months — and patterns of electricity demand — in the future."[20]

Grid outages are more likely during high, heat wave-driven local demand that causes stress on distribution systems. Satellite remote sensing data during such outages have shown that local solar electricity can help mitigate grid failures resulting from these conditions. Additionally, when grid outages are unavoidable, solar PV systems with battery backup can help communities continue to generate power to serve vital needs: "Consumers already pay an average of [the equivalent of] 40 kWh for uninterruptible power supplies (UPS). A solar PV system integrated into the UPS can, for a relatively small incremental cost, extend the power supply backup capacity, particularly during the worst outages."[21]

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[18] "Energy Costs Push Consumer Prices Higher,"msnbc.com. November 15, 2007. <http://www.msnbc.msn.com/id/21816416/>.

[19] Kelly, William. "Utility Bills a Growing Problem for Californians," *California Energy Circuit*. May 19. 2008. <http://www.californiaenergycircuit.net/displaystory.php?task=show&sid=3130&un=&ut=&pd=&seid=1211232150>.

[20] Miller, N.L., K. Hayhoe, J. Jin, and M. Auffhammer, "Climate, Extreme Heat, and Electricity Demand in California," *Journal of Applied Meteorology and Climatology*, In Press, 2007.

[21] Herig, Cristy, *Assessing Roof Top Solar-Electric Distributed Energy Resources for the California Local Government Commission*, National Renewable Energy Laboratory, 2000, Attachment 3.

Backup energy sources are critical for minimal lighting, refrigeration, fans, street lighting, traffic control, security systems, critical computer functions, medical equipment, and communications until electrical service is restored. Currently, propane, gasoline and diesel generators are the main sources providing this emergency backup energy during grid failure, and these are typically found in only in selected sites such as fire stations, hospitals, and computer dependent businesses. However, these generators are noisy, omit toxic fumes, and dangerous if fuel is stored improperly. Solar energy sources are quiet and discreet, and can provide consistent, long-term power during times of emergency when used in conjunction with a properly sized battery backup system.

Solar Safety Net SWOT Analysis

Strengths	**Weaknesses**
• Zero carbon technology (except during manufacturing), requires no water for cooling and does not release air emissions • The SSN can be sized smaller than other off-grid system designs, since it addresses only vital loads • Ease of visual integration • Stable technology • Emergency electricity source • Primary electricity reduction • Low maintenance • Supported under a variety of grant schemes and tax incentives • Ideal in remote locations or those seeking off-grid solution • Highly appropriate for office and other commercial uses which have large electricity load demands	• High initial cost • Relatively long payback period (up to 20 years) • Subject to damage by hurricane-force winds[22] • Subject to snow and ice buildup[23] • Low performance in cloudy and stormy weather; Solar PV systems require direct solar access, making it less reliable than fossil generators in the short-term without a properly-sized battery backup system • Battery toxicity and potential disposal issues • Subject to vandalism and theft
Opportunities	**Threats**
• Climate change/global warming • Integrate into new developments at the design stage • Supply of power to outstations • Generally less contentious than wind installations • New, cheaper PV forms are in R&D stages. Building-integrated solar PV is currently the most economical option currently available (e.g. acting as roof tile, shading in glazing)	• Perception of low operational energy conversion efficiency due to the unconcentrated nature of the energy source (direct sunlight) • Investor Owned Utilities (IOUs) • Larger power providers • Existing products (e.g. diesel generators) • Reduction of tax incentives for photovoltaic systems

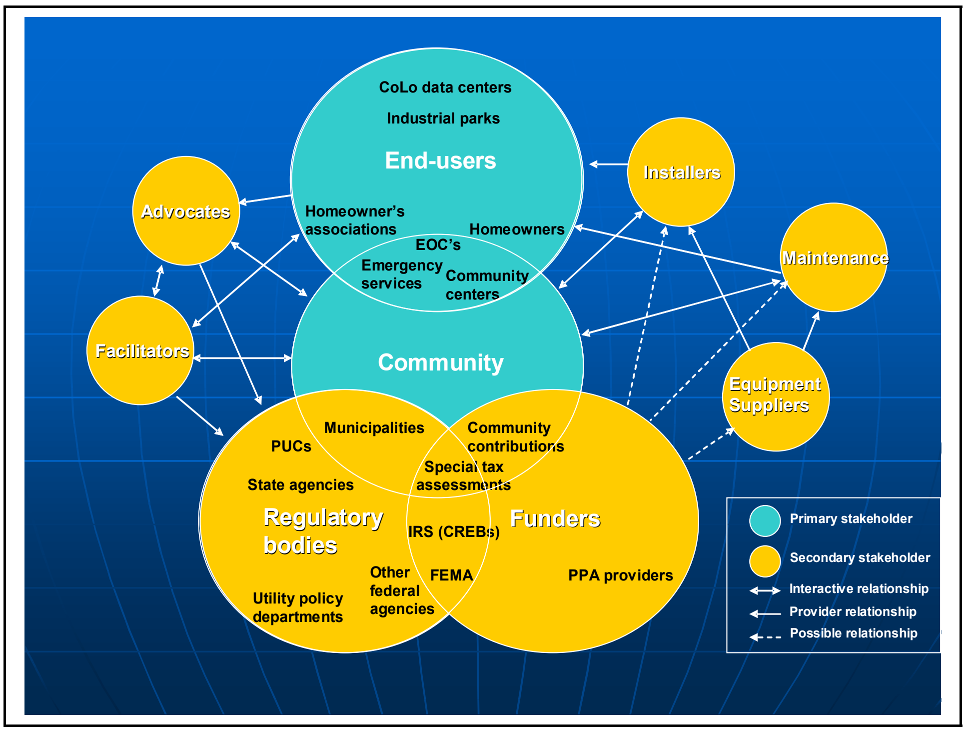
[22] Panels may need to be designed for quick removal.
[23] In climate zones that witness considerable snow and ice, the SSN may need a heating element to melt ice during the night.

Solar Safety Net Stakeholders

Stakeholders for an SSN are categorized based on interests, needs and requirements. Six general stakeholder categories were identified in this research: End users; advocates of an SSN for their communities (and facilitators who make its implementation possible); service providers; government regulators; utilities and the California Independent System Operator; and funding sources interested in investing in disaster mitigation, renewable energy, or both.

The relationship between the different stakeholders is illustrated in the diagram below (Figure 3). In many instances, members of one stakeholder group overlap with one or more other groups. For example, those who use the system on their property could also maintain the system. Or end users could serve a dual function as advocates and/or facilitators. In each role, the needs of these stakeholders would be different.

Figure 3. SSN Stakeholder Map



In addition to the stakeholders who are directly involved in the SSN project, we also interviewed several other energy experts:

Mark Bollinger: Lawrence Berkeley National Laboratory
Peter Palensky: Demand-response expert, Lawrence Berkeley National Laboratory
Carl Weinberg: former director of research and development at PG&E

1) End Users:

The end users we spoke with included those who will have the SSN installed on their property, as well as those who, in the event of a blackout, would use the SSN's emergency services (including residents, business owners, and visitors to an area during a power outage). We interviewed several potential end users of the SSN by phone and in person to determine needs, including a range of residents and business owners in areas where SSN prototypes were being installed as well as in areas where the SSN may be a good candidate for installation in the future. The regions varied in size and remoteness, and included Point Reyes Station, Bolinas, Stinson Beach, as well as the Town of Canyon and the City of Berkeley.

The main concern of end users is for the SSN to reliably provide the minimal amount of power in order to address basic needs during a blackout. Residents and businesses in the area expressed several other needs, both vital and non-vital. These included:

- A robust, reliable, and safe system.

- Must be able to be optimally configured, and must be able to provide optimal generation capabilities to meet the basic needs of the community that it serves. This includes: basic lighting, communication, water, heat for people and equipment, and food storage. The extent of a community's electricity needs is determined in part by its external infrastructure. For example, a system built in an area where well water is used would require more power than in areas that use municipal water systems.

- Unlike other solar PV systems with battery backup, which are commonly designed for a residence or business with relatively stable load demands, the SSN's design may have to take varying load demands into account as a direct result of a blackout. For example, in a system which includes a central gathering place, such as an emergency center or focal household, the SSN's design should account for a potential overflow of people at that location.

- For multi-site systems, such as a neighborhood micro-grid or an apartment building, the system should provide for equitable distribution of power during a blackout. This could be in the form of a checklist and a designation of roles (established during the design phase of the SSN). In this latter scenario, everyone in the community would have to understand and agree on the load requirements of the system during a blackout, agree on which specific loads would be unnecessary, and respond accordingly by manually shedding those unnecessary loads.

- As the demand response technologies advance, this need could also be met through an automated system, which would be configured for more restrictive load management during a blackout than during periods of normal grid operation.

2) CS Advocates and Facilitators:

At the time of this writing, the first SSN design is being implemented at the Dance Palace Community Center in Point Reyes Station, California (see pages 20-22 for a more detailed description of this prototype). As the concept of the SSN becomes more widespread, and community interest continues to build, its advocates and facilitators will be critical to help determine the larger, system-level requirements needed for the optimal system design for their own communities both during emergency and non-emergency periods. They may also help installers and end users in the actual implementation of the SSN in their community.

The facilitators and advocates of CS/SSN projects interviewed included:

Peter Asmus: Pathfinder Communications
Ty Cashman: Solar Economy Institute
Tim Rosenfeld: Marin Energy Management Team

Some of the needs identified by this stakeholder group overlapped with other stakeholders:

- The system should be able to provide renewable power.

- The accessories (i.e. batteries or other energy storage devices) should contain materials that are low in toxicity, and have a minimal environmental impact when disposed of. Components should have a relatively long lifespan to minimize the frequency of waste generated.

- The system should be able to provide the community with a sense of energy independence. A community that "owns their own electrons" tends to be more educated about (and in some cases more willing to advocate) where their power comes from. A more energy independent community may also have a greater sense of responsibility about their power consumption.

- During grid failure, power consumption should be able to be limited for non-vital resources, and should be increased in vital areas (such as community centers). Ideally, power from solar assets in non-vital areas could be diverted to vital areas, a form of CS.

- The system design should be able to meet regulators' statutory requirements for meeting disasters (in order to qualify for FEMA funding).

- A periodic maintenance plan should be put in place based on how the community wants to keep up the system (i.e. will maintenance be contracted out, or will the owner of the property on which the system is installed be designated for its maintenance?).

- The system should have a positive cost-benefit analysis, as well as positive risk and vulnerability assessments for potential funders.

- The system should be able to provide reliable power for an extended period of time. The current prototype is rated for 5 days of battery backup power in the event of constant cloud cover or grid failure. With enough sun between those periods of shading to charge the batteries, the SSN could provide a consistent power source that would only be limited to the lifespan of the equipment.

- The SSN should have a modular structure, with the ability to expand the system as the community grows.

- Size of the battery array would be a consideration.

- In coastal areas subject to hurricanes, the array should be able to be temporarily disassembled and stored in a protected location.

- The system must accommodate a variety of weather conditions (ice on panels, hurricanes, earthquakes).

- The power demand should meet the needs of the community. In community centers designated as disaster relief sites, the following vital needs will be provided by the SSN:

  - Powering a facility which can sleep 25 (three or four large rooms)
  - Feed 50-100 people
  - Charge cell phone batteries for up to 100 neighbors
  - Purify water

3) Service Providers:

Service providers fall into three categories: Vendors, installers, and those who provide ongoing system maintenance (both in times of a blackout, as well as during periods of normal grid operation). At least three representatives of the solar PV industry in West Marin were interviewed in person primarily to gain insight to the technical needs and concerns of the SSN. Questions related to procurement, installation, supplies, and finance. Those who were interviewed included:

Darren Malvin: Pacific Green Energy
David Willard: Sustainergy Systems
Tom Willard: Sustainergy Systems

The industry representatives interviewed provided a tour of several potential sites in West Marin County, explaining how those systems would be installed and configured. Some of the factors they identified to make the SSN a near-term commercial enterprise included:

- The system should use technology that is easily accessible, so that, in the words of one interviewee, “anyone can put it in who knows what they’re doing”, or can easily contract out to a local engineer. This is particularly important as the system scales upward, becoming physically larger or more complex within a community.

- Energy storage and management systems to prevent deep discharge of batteries in systems with extensive AC-side coupling.

- Provide a system for a periodic maintenance plan.
- Periodic system testing.

4) Government Regulators:

Federal, state, and local government representatives were also interviewed either by phone or in person. The interviewees represented agencies acting in the capacity of either facilitator or funder, or both. Others, such as city officials, were also potential customers of the SSN. However, since stakeholders were broken out by need in this analysis, this category focuses on government agencies responsible for policy. Public funding sources will be covered later in the analysis. Government representatives interviewed included:

Jon Bertolino: Sacramento Municipal Utility District
Robert McCord: Region 9 Mitigation Grants Coordinator, Federal Emergency Management Agency (FEMA)
Nils Moe: Assistant to the Mayor, City of Berkeley
Richard Sexton: FEMA/Department of Health Services Emergency Management Institute
Don Smith: Director, Bolinas Community Public Utility District
Nancy Ward: Region 9 Administrator, FEMA
Rebecca Wagoner, CA Governor's Office of Emergency Services Mitigation Grant Program

In order to facilitate the deployment of the SSN, the following characteristics need to be addressed to satisfy government regulators:

- Provide essential services: Robust, dependable system to meet backup system requirements for fire, police, and medical services.
- In municipalities participating in climate action plans (such as U.S. Mayor's Climate Protection Agreement), the SSN should be able to help meet emissions reductions standards for government buildings.
- Overcome cost barriers, which may be mitigated by Clean Renewable Energy Bonds (CREBs) and other low- or no- interest financial instruments. Rebates from the California Solar Initiative (CSI) have consistently been dropping to induce manufacturers of renewable energy components to improve product and production technology in order to stay competitive with other power sources. Technologies related to the SSN must also continue to fall in price in anticipation of these reductions in subsidies.
- Provide the required generation efficiency. Performance-based incentives, which mandate minimal operational efficiency standards as a condition of rebates, are the key regulatory factor related to efficiency.
- Overcome both technical and policy barriers to using solar energy. Some of the barriers mentioned include:

- Inverter requirements: California law requires that solar energy systems isolate any power generated by solar PV systems during emergency grid failures, citing safety concerns for utility maintenance crews, potential damage to customer or utility equipment, delays in restoring normal service after a blackout, and other potential liabilities.[24] Appendix B provides an overview of the standards used to isolate inverters from the grid during a blackout, and of the methods used by inverters to prevent unintentional "islanding" by solar PV.

  To isolate themselves from the grid, the majority of grid-tied inverters which are currently on the market simply shut down during blackouts. When this happens, the only power source available during a disaster would be the system's backup batteries. This scenario automatically imposes a time limit on the power consumed during the period of grid failure to the kilowatt-hour capacity of the battery array, and requires additional storage capacity and equipment, increasing the costs and environmental issues of the backup system.

  A potential solution to the situation above would be a micro-grid concept, where the SSN would generate power in a closed circuit – independent of the utility grid – during a blackout. In this scenario, power would continue to be generated by the solar PV array to serve the micro-grid, even while the larger utility grid was down.

- Net metering regulations: These programs were not designed with the SSN service in mind. At present, California utilities will only pay retail rates for power produced by distributed generation (DG) systems to meet onsite loads. Lifting these restrictions for SSN systems would allow investors in these systems to see an earlier positive Net Present Value (NPV), which would help to make the SSN more financially competitive with traditional backup systems (systems which do not use renewable power, and which do not provide additional sources of power to the grid during peak periods of demand).

- Potential issues navigating the implementation of an SSN at facilities requiring greater security, such as a national research laboratory.

- Potential conflicts and delays with local permitting processes.

5) Utilities and California Independent System Operator (CAISO):

In grid-tied SSN designs, private and public utilities could be seen as SSN service partners. Together with quasi-governmental regulators such as the CAISO (which manages transmission services for the majority of California's utility grid), utilities also implement policy and regulate grid operations. In addition to facilitating the interface with the grid from both a technical and policy perspective, the utilities help to coordinate load management, provide maintenance resources, and at times invest in energy generation and energy management systems. Two members of PG&E were interviewed, as well as the independent energy experts mentioned above, on the needs and requirements that a utility and the CAISO would have regarding the SSN. Those interviewed included:

[24] Bower, Ward and Ropp, Michael, *Evaluation of Islanding Detection Methods for Utility-Interactive Inverters in Photovoltaic Systems*, Sandia National Laboratories, November 2002, p 13.

Paul Carp: Senior Project Manager, Customer Energy Efficiency Department, PG&E
Lucian Ion: Energy Policy, Planning, and Analysis, PG&E

Some of the concerns that utilities had for effective grid-tied SSN operation included:

- Safety and reliability, especially if operating in a micro-grid capacity.
- CAISO has to know how power resources generated from independent systems are dispatched to the grid.
- Requires significant coordination and cooperation with the utilities.
- For a micro-grid, ensure that any fluctuations in output voltage or frequency are stabilized at a constant 60 Hz frequency when sent back to the larger utility grid.

Some of the additional needs that the SSN could provide to utilities in the future are:

- Avoided costs, e.g., new peaker power plant investments.
- Help the utility meet RPS and AB 32 targets, and reducing the regulatory risk of the potential for increased carbon reductions in future legislation.
- Provide power demand and power generation forecasts for communities using the SSN: With the right protocols, Web-based technologies could collect data and feed to the CAISO to forecast power supply and power demand levels.
- As more communities employ the SSN service, the increased scale of distributed generation would help to stabilize periods of peak demand on the utility grid (and possibly avoid rolling blackouts).

6) Funding Sources:

Funding for the SSN would closely mirror the funding options for similarly scaled solar PV systems. Funding sources would also include sources that typically finance emergency preparedness systems and programs. Potential funders of the SSN were divided into two general categories: private and public sector sources.

Private: These funding sources include banks, venture capital or angel investors, and community donors to the system.

Public: If the SSN was considered a public good, it could qualify for public financing by federal, state, and local agencies – agencies which provide grants and issue bonds to renewable energy projects and emergency preparedness systems. Some possible public funding methods:

- Use of the property tax system, in which case the city or county in which the system is located would be a stakeholder. The municipality would fund the installation by levying a 20-year special tax assessment on the property where the SSN is installed. The City of Berkeley is leading the way on this type of public financing through its “Berkeley First” program, though it is still working through some regulatory snags.

- Tax-exempt bond financing: The SSN would most likely be able eligible for federal tax credits and zero-interest Clean Renewable Energy Bonds (CREBs). In this case, the Internal Revenue Service would be a stakeholder beyond its current role in simply providing federal tax credits.

- FEMA as a stakeholder could provide the most opportunities for funding under their mitigation planning and pre-disaster projects.

- Once the SSN is established, the federal Environmental Protection Agency (EPA) could be a potential stakeholder through its Green Energy Partnership. This partnership can provide additional brand recognition and leverage both private and public funding.

System Design Selection

Cost, reliability, compatibility, and the ability to mitigate environmental impacts associated with energy are all important selling points for most residential and commercial solar PV systems. To date the vast majority (over 90%) of all residential solar PV systems are grid-tied only systems.[25] On average, the incremental cost of the battery backup starts at 25%, and can be much higher depending on the application.[26] Current rebates apply only for grid-tied systems and are not available for upgrading an existing system to include a battery backup system.

Solar PV grid-tied systems with battery backup systems (see Figure 4[27]) are still being installed by businesses and residences all over the world to power a wide range of building equipment, lighting, appliances, computers and communications equipment. This type of solar PV system has the same features and benefits of a grid-tied system, but with the additional benefit of uninterruptible power during a grid failure. This system can take advantage of the net metering, the solar rebate program (minus battery system costs), and grid connection benefits. With the battery backup, you are still connected to the grid as with the standard grid-tied system, but when the utility grid is down, the battery backup delivers the only power to critical appliances and electrical devices (refrigerator, radio, electric heater, computers, etc.). These solar PV grid-tied battery backup systems are capable of generating, storing, and managing DC-AC power using two possible methods:

- *DC Coupling:* In this case, the inverter connected to the solar PV system will shut down. The battery system however, is completely isolated from the grid and the solar PV system and provides AC power — whether the grid is up or not — through its own inverter. The solar PV system would charge the batteries through a separate charge controller. Battery arrays would need to be sized to the loads they would be providing power to.

- *AC Coupling*: Although the inverters connected to the solar PV arrays will still shut down during a blackout, AC-coupled systems are centralized systems which intelligently monitor the solar PV system, the battery backup system (which converts to AC power through the centralized system, and *not* through its own inverter), and the grid performance. It will automatically switch to a battery backup system when the grid goes down to isolate any localized power. Since AC-coupled systems draw all AC power produced, it also manages battery charging and discharging.

Either method gives protection from blackouts or any other power losses that could span various grid failure scenarios:

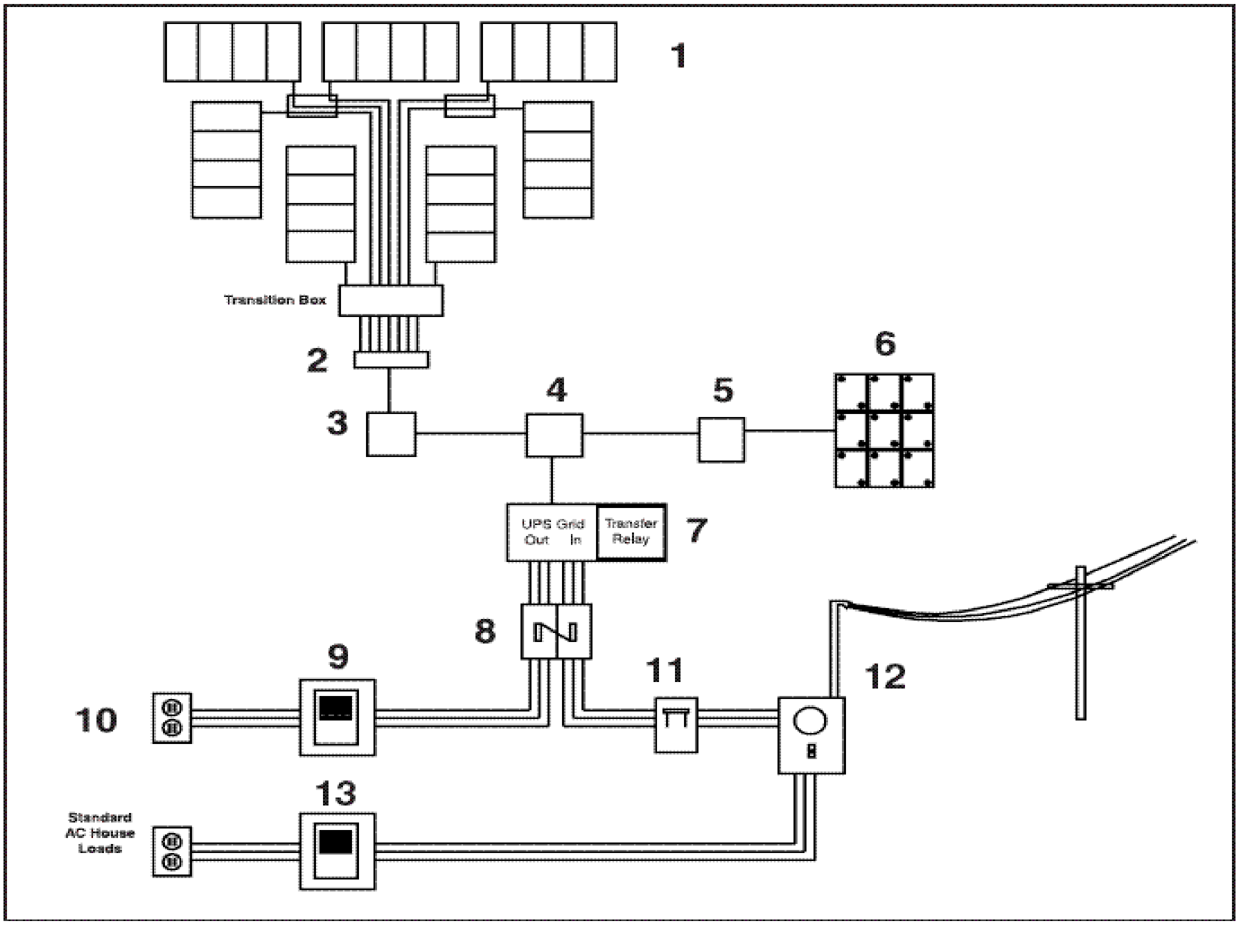
[25] "Farming the Sun," *Port Townsend Leader*, October 3, 2007. <http://www.ptleader.com/main.asp?SectionID=21&SubSectionID=21&ArticleID=18912&TM=65644.84>.
[26] "Technical Information on Photovoltaic System Components," *Natural Resources Canada*, September 27, 2002. . < http://www.canren.gc.ca/prod_serv/index.asp?CaId=101&PgId=549>.
[27] Nogueira, Milton, and Black, Andy, "Basics of Solar Energy: Photovoltaics (PV)," *Northern California Solar Energy Resource Guide,* 2003, p. 4.

- *Scenario A: Emergency*
    - Causes: Weather-related blackouts, demand response event
    - Duration: Expected to last less than a day to several days
    - Strategy: Residences/community center(s) operates independently and load shed/load shift as needed

- *Scenario B: Disaster*
    - Causes: Floods, wildfires, sabotage
    - Duration: Expected to last several days to several weeks
    - Strategy: Residences/community center(s) operates only vital loads and share power

- *Scenario C: Catastrophe*
    - Causes: Major earthquakes, tsunamis, hurricanes, sabotage
    - Duration: Expected to last several weeks to several months
    - Strategy: Residences shift to vital loads (or completely off) and available energy is allocated to the community center(s) to increase its power

Figure 4. Solar PV Grid-Tied Battery Backup System



1. ***PV Array:*** A group of PV modules wired in series or in parallel or some combination thereof to obtain the desired output.
2. ***Ground Fault Protection Unit:*** Protects the equipment from a short circuit.
3. ***PV Array Breaker:*** Allows power from the array to be shut off so that work on other parts of the system can be performed in safety.
4. ***Charge Controller:*** Monitors the battery bank to keep it fully charged while protecting against overcharging.
5.***Battery Bank Breaker:*** Allows power from the battery to be shut off so that work on other parts of the system can be performed in safety.
6. ***Battery Bank:*** A group of batteries wired in series or parallel or some combination thereof to obtain the desired output.
7. ***Inverter:*** A device that changes electricity from direct current (DC), generated by PV panels and batteries, to alternating current (AC), standard power used in most homes.
8. ***UPS/Bypass Breaker Sub-panel:*** A device used to switch to battery power if the grid goes down.
9. ***The UPS Sub-panel:*** Holds circuit breakers for those circuits supplied by the UPS system.
10. ***UPS Circuits:*** Selected AC circuits that will receive power if the grid goes down. The number of circuits served depends on the size of the battery bank.
11. ***PV/Grid Disconnect:*** A switch that turns off the power from the PV array and battery bank so that work on the AC part of the system can be performed in safety, either in the house or on the utility grid.
12. ***Main Service Entrance:*** The breaker box where the grid meets the house. Has a meter to measure the amount of electricity consumed. The meter will turn backward if the PV electricity generated exceeds the electricity used. Time-of-Use meters can be used to keep track of when electricity is used or excess is generated. Utility companies can then charge more for use in peak periods. PV systems make more for watts generated in peak periods.
13. ***Standard Sub-panel:*** The standard AC circuit breaker box in most homes.

Point Reyes Station: An SSN Pioneer

West Marin's first prototype SSN system was installed May-June 2008 at the Dance Palace, the community center of Point Reyes Station which also serves as a medical annex during emergencies. The installer, SunFirst!, is a small West Marin-based solar installation business.

The exact final design was shaped by the California Solar Initiative (CSI) rebate and a tight budget. The system equipment cost approximately $45,000 and includes a 10 kW solar PV array hybrid system with a 5 kW array connected to grid-tied inverter and a 5 kW solar PV array tied to an inverter backed by Absorbed Glass Matt (AGM) lead acid batteries. The latter system will be able to provide power to the Dance Palace during grid failures. There is room on the Dance Palace roof for a total of 30 kW of solar PV that could be built and shared with the nearby firehouse and other local consumers, if current regulations were changed to allow for CS.

The Dance Palace system is equipped with an SMA Sunny Island and two SMA Sunny Boy (5 kW) inverters. It is expected that the system will provide 9 kW at peak and even in dense fog will still be able to produce 20-30% of its normal power and provide a minimum 2 kW of capacity. The backup batteries can handle up to 5 kW of electricity loads and will be able to power vital critical loads at the community center for up to a week. These critical electrical loads include:

- Fire alarm.
- Indoor and outdoor emergency lighting.
- Core office, e.g., computer and communications.
- Sound system (entertainment is a primary service provided by the center).
- Refrigerator (only charged during the day).

Part of the design of the SSN at the Dance Palace involved rethinking how to rewire loads which were considered vital during grid failure, including electrical systems that could provide basic functions for any Dance Palace events already in progress at the time of a blackout. In order to bring the SSN up to current electrical code, designers separated out these loads, which were originally on three different sub-panels, and put them all on their own dedicated fourth sub-panel. Keeping these loads on the same panel allowed the 5 kW emergency backup system to safely remain within its 60 amp peak load capacity.

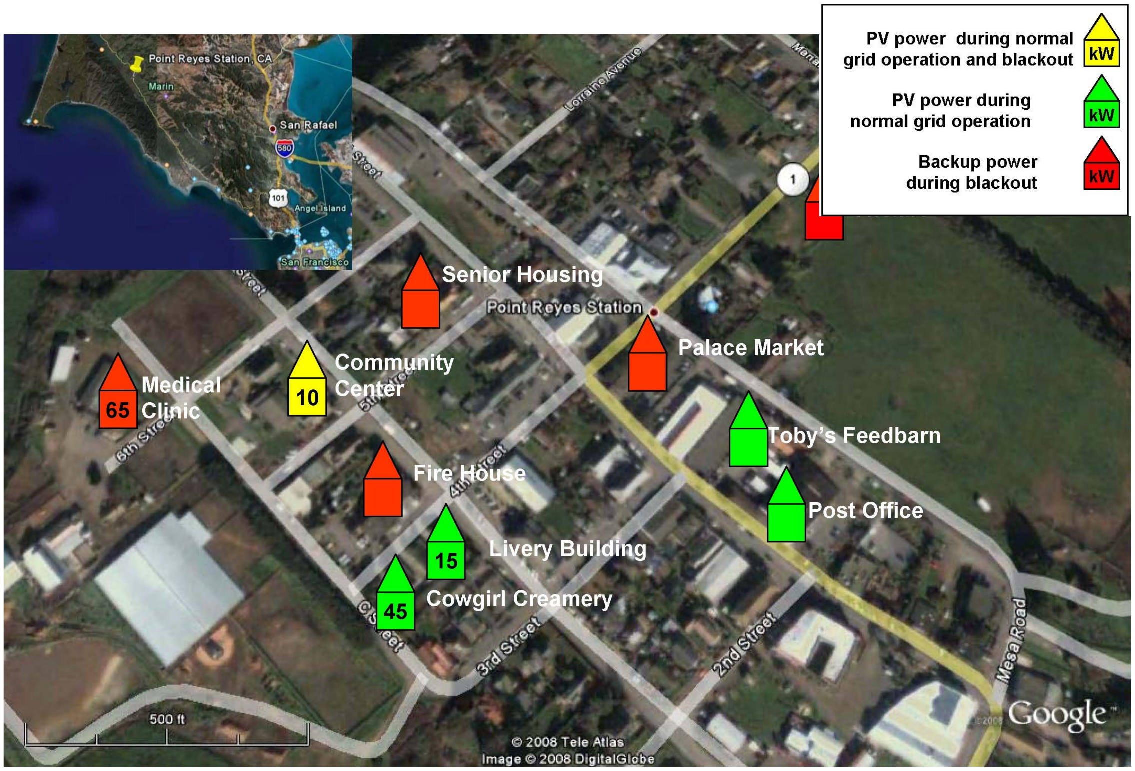
In Point Reyes Station, a number of public and private grid-tied only PV systems have been installed that would not be able to produce electricity during a grid failure. These include: West Marin School gymnasium (24 kW), which is also the designated emergency shelter for Point Reyes Station, Marshall, and Olema; Cowgirl Creamery (45 kW); The Livery Building (15 kW); Toby’s Feedbarn and the U.S. Post Office Building (20kW), a shared property.

Currently the Point Reyes Station medical clinic, the firehouse, the Walnut Place senior housing, and the Palace Market all have generators with automatic transfer switches when switching from grid power to generator power, which cuts the building off from the grid during a blackout. The

KWMR radio station, Greenbridge Gas, and Horizon Cable have generators with manual transfer switches.

Figure 5 shows the locations of these potential SSN/CS assets.

Figure 5. Point Reyes Station SSN Assets



Based on this preliminary review our recommendation would be for Point Reyes Station to develop and expand the SSN/CS concept in phases:

1. Build out grid-tied battery backup systems for all community assets, e.g. the firehouse, medical clinic, and elementary school.

2. Create an SSN micro-grid by interconnecting all of these SSN assets under the rationale of providing a disaster relief role using the existing distribution infrastructure combined with a master relay, inverter, charge controller, and automatic disconnect switches where needed.

3. Expand the SSN micro-grid by interconnecting private generating and storage assets using existing distribution infrastructure combined with automatic disconnect switches where needed.

Currently, the approved technologies on the market which can facilitate such a micro-grid environment are limited either by system size or by a limited ability to intelligently manage power distribution between times of normal grid activity and times of blackouts. Since an SSN emergency micro-grid is not at present compatible with accepted utility practice, or with inverter design standards, the recommendations made above would be relevant to a time when utility practice and perhaps inverter technologies have developed further.

The SSN Concept

A solar PV grid-tied system with battery backup design for the single building system was selected as the SSN prototype for the Pt. Reyes Station installation. However, in the future, sites such as this one could be served by micro-grids which connect several buildings in a community rather than a single-building system (a design which restricts power to loads within that building, or to loads located behind a single meter).

Although current regulations prevent such a design, an SSN micro-grid would provide the most benefit to communities during a blackout by generating power from multiple solar PV sources in a community and storing it through batteries (or fuel cells) at a common point or possibly distributed points within the power network. Small fossil fueled auxiliary generators can be linked in to the micro-grid to add resiliency and robustness to the whole system. There are several reasons why such a system makes sense. First, solar PV arrays could be sited on rooftops or open spaces that receive the most sunlight. With this configuration, residences or businesses on the SSN micro-grid could take advantage of the power it provides – even though their property may be located in partial or full shade. Second, a micro-grid which can safely generate power through the solar PV system during a blackout would not have to rely on batteries during the entire time that the grid is down – only during evening hours or during times when the panels are shaded or damaged. Third, a micro-grid design which provides multiple solar PV arrays on multiple rooftops provides a modularity that makes it more resilient than would a single PV array on a single rooftop: if one part of the power generation system is knocked out, the other arrays can continue to generate power. Finally, on a social level, the fact that power is being produced and widely distributed to residences, businesses, or organizations within a community experiencing grid failure can lend a greater sense of unity to that community during times of emergencies.

During a grid failure the load management panel or an emergency sub-panel would be able to selectively power designated vital loads. The power management strategies will be determined by the grid failure scenario and will vary over time in order to optimize the overall system performance. These systems can be operated during normal grid operation as well to provide demand response services for the larger utility grid.

To address the interconnect safety concerns during grid failure, automatic disconnect switches would be installed at the site with the ability to isolate the site from both the SSN micro-grid system and the utility grid.

By introducing a master relay, an inverter, and a charge controller with common communications protocols, it would be possible to create an emergency micro-grid with the ability to network the site with other grid-tied systems using battery backup, grid-tied only systems, systems with battery backup only, and/or other standby emergency power generating assets such as generators. Having shared resources will make economic sense and allow the pooling of resources and redundancy, converting the SSN into a form of CS.

These concepts are shown in the site- and system- level operational diagrams below.

Figure 6. SSN Site Level

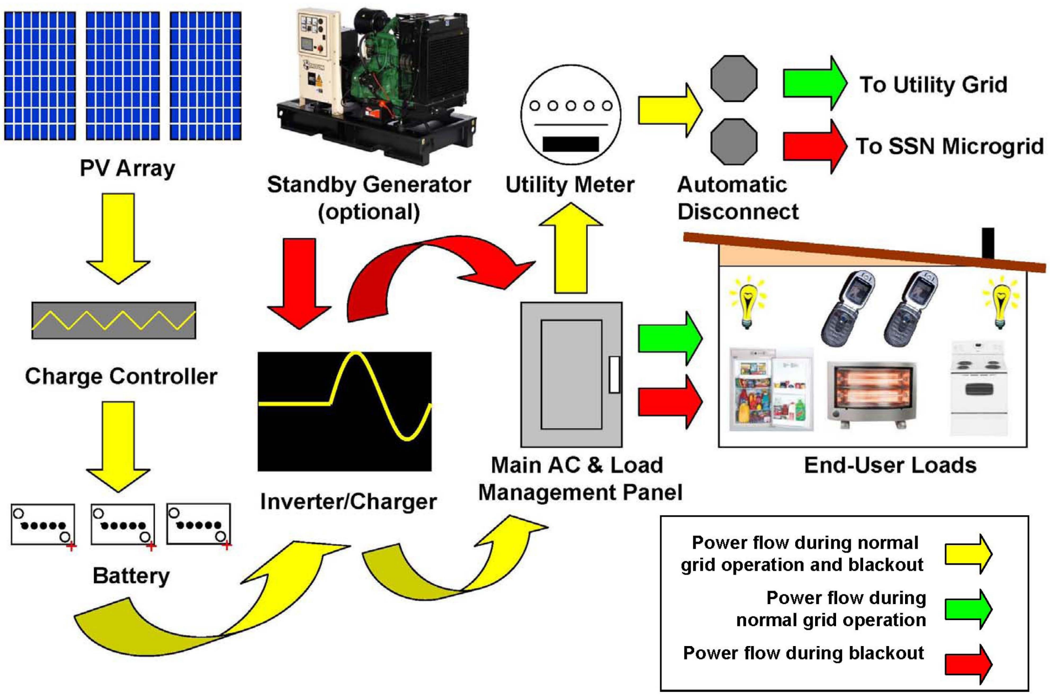
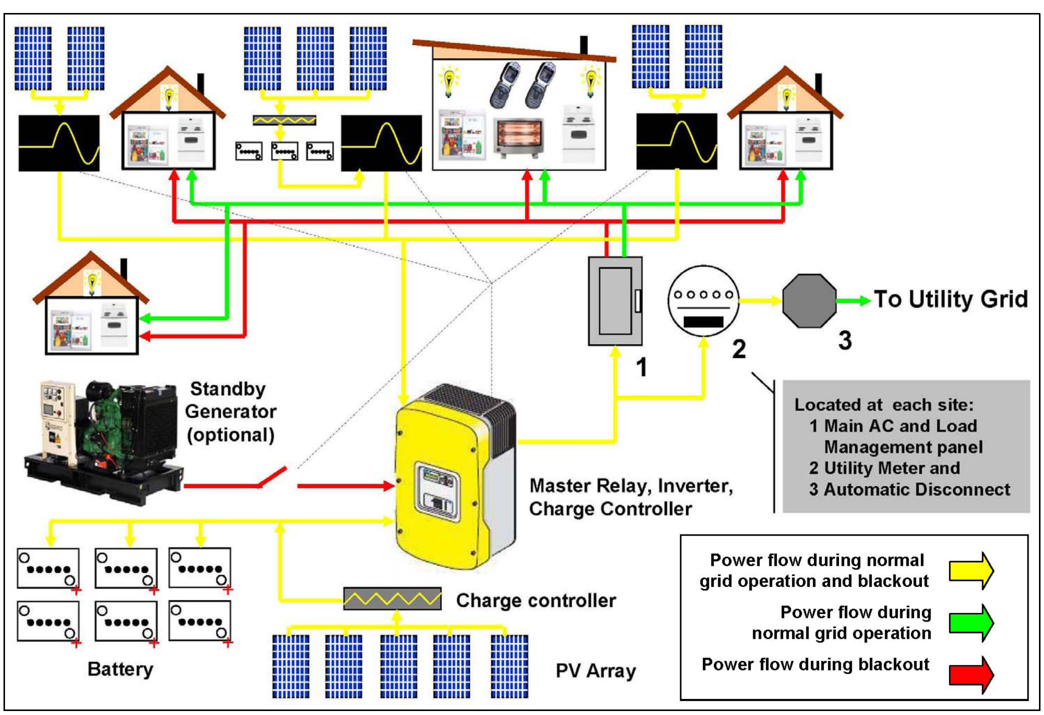


Figure 7. SSN System Level



SSN Micro-storage Implications

Some kind of battery back up system is essential to the SSN, but it need not be as large as a traditional off-grid battery system. There are two important functions for storage in an emergency solar network:

(1) To provide power to loads during the nighttime and during very cloudy or foggy weather.

(2) To provide a place to store excess power produced by the solar PV panels when there is insufficient load on the system. While batteries can only store so much power, other options may be available, as explored later in this section.

When the grid is functioning, the SSN system acts as the backup for the solar PV array at the home or business, providing the property with all the nighttime electricity it can use. When the grid is down, the battery bank is required only to provide sufficient storage for vital needs — critical minimal loads appropriate to times of emergency.

In addition, it happens that present-day homes contain what might be called "distributed micro-storage." Many appliances now have built-in batteries, and are meant to be used with battery power on a daily basis. These items include shavers, laptop computers, iPods, cell phones, portable power tools, among others. Battery-powered appliances can be charged and used during the day when the panels are functioning and will operate for an adequate period at night on their own batteries. No traditional battery bank capacity needs be installed to cover such appliances.

There is also thermal (non-electric) micro-storage in the refrigerator/freezer and in the hot water heater. Heat stored in the hot water during the day can be used at night, and the refrigerator/freezer will hold its "coolth" through the night if its inner thermostat is turned down to a slightly colder temperature while the solar PV panels are working.

Also, the need for storage can be reduced by scheduling. There are a number of electric tasks that can be accomplished during full sun hours, for example: clothes washing, cooking and computing.

In a home, business, community center or neighborhood with a fully-implemented SSN system, there might be a way to access the large battery capacity of one or two plug-in hybrid cars. As plug-in-hybrid technology becomes available, their batteries (which currently carry between 5 and 9 kWh of energy[28,29]), can be utilized as a large source of power storage. Plug-in hybrid cars are an ideal adjunct to an SSN because, during extended blackouts resulting from large-scale disasters, a vehicle that can be charged and run on solar PV electricity can be used in suburbs and remote sites for periodic trips to stores or emergency supply depots for food and other supplies.

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[28] Wald, Matthew L. "A Plug-In Conversion for Prius," *New York Times*, April 27, 2008. http://www.nytimes.com/2008/04/27/automobiles/27PLUGIN.html?pagewanted=1.

[29] Moore, Bill, "The Promise of Plug-In Hybrids," *EV World*, September 21, 2005. <http://www.evworld.com/article.cfm?storyid=897>.

In addition to the storage of energy for future use, the SSN backup system could act as a reservoir for handling excess power in times when the loads are smaller than the incoming solar energy. This excess energy can be shunted to hot water, refrigerators, and batteries until they are full. At that point the remaining excess power would be grounded.

Federal, State, Local SSN Funding Options

Federal Emergency Management Agency

The SSN could be eligible for federal emergency management mitigation grants. The Disaster Mitigation Act of 2000 bases eligibility for hazard mitigation grants from the Federal Emergency Management Agency (FEMA) upon the condition that a state or local jurisdiction participates in a local hazard mitigation plan that meets federal guidelines.

The Pre-Disaster Mitigation (PDM) program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning as well as the implementation of these projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. PDM grants are awarded on a competitive basis.

FEMA administrates its mitigation and pre-disaster mitigation grant programs through the state and counties. The California Governors Office of Emergency Services (CA OES) would be the lead agency for the SSN pilot and the Marin County Sheriff's Office would be the lead local agency (for county funding, FEMA funds are distributed through the chief law enforcement body).

Solar energy has already played a role in some of the nation's best mitigation practices, such as providing power to wastewater treatment plants and interoperable emergency communications. Allegany County, Maryland, for example, found a way to provide its response agencies with advanced telecommunications services such as enhanced interoperability, mobile high-speed data terminals and more by using innovative wireless network communication technologies powered by solar PV panels.[30]

Marin County could design a FEMA pre-disaster hazard mitigation pilot project to achieve critical funds for equipment, brand equity, and key government stakeholder buy-in to the SSN. To increase the possibility of funding, the SSN concept would be incorporated into a larger county/regional pilot based on renewable resources and scenario planning for emergencies, disasters and catastrophes. Solar powered energy becomes more important to communities as emergencies escalate into disasters and catastrophes with traditional power sources destroyed or inoperable for longer periods.

A proposed SSN statement of work should include long-range view of community disaster relief scenarios and planning at the state, regional, city, and neighborhood levels. It could also propose an integrated approach to protect Marin County resources designated by FEMA through multi-hazards risk analysis that would encompass floods, earthquakes and winter storms.

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[30] Please see National Incident Management System (NIMS) Smart Practice: 02-06.
<http://www.fema.gov/emergency/nims/nims_smart_practice.shtm>.

Successful implementation of such an SSN pilot project could have national implications:

- It could serve as a FEMA best-practice to integrate hazard mitigation and local planning activities.
- It would increase credence for solar energy and other renewable energy sources to be incorporated into FEMA program guidance for disaster mitigation and recovery grants.

Leveraging State and County Initiatives

The pilot program would create a synergy with state legislative mandates for climate change and renewable energy, including various new solar, distributed generation, and smart grid policy initiatives. In an interview on May 1, Henry Renteria, CA OES director, voiced support for a sustainable approach to emergency preparedness.

The SSN pilot project could open the door for greater reliance upon solar PV systems in Marin County's proposed CCA program by providing new avenues for funding solar PV projects. For example, the SSN could be subsidized by new FEMA funds, displacing current funding for fossil fuel-burning backup generators. The SSN pilot project also would help to implement the Marin County wide General Plan (2.7: Natural Systems and Agriculture Element) commitment to minimize greenhouse gas emissions.

Social Return on Investment (SROI)

The following evaluation of the SSN considers the five design principles of Edwin Datschefski's "Total Beauty" framework,[31] which attempts to measure the sustainability a product or service:

- **Cyclic** – Materials are organic and able to be continuously recycled in a closed loop.
- **Solar** – Manufacturing and use are based on renewable energy.
- **Safe** – There is no waste.
- **Efficient** – Manufacturing and use involves 90% less energy than 1990.
- **Social** – Promotes basic human rights and social justice.

Cyclic

The SSN consists of solar panels, batteries, inverters, and other components that can be largely disassembled and recycled. Parts are all off the shelf. The lack of custom-built parts means less waste generated in materials packaging, etc. due to one-off production.

Due to the Second Law of Thermodynamics, there is always some loss of useful energy with each transformation and use. Therefore, strictly speaking, energy can never be recycled and is thus outside the scope of the cyclic analysis.

How to measure:

- Benchmark greenhouse gas emissions as a result of SSN power generation against areas where electricity is produced by fossil fuel plants.
- Track the percent of recyclable material in components produced by the manufacturers.
- Track the types of materials that local waste collection companies can divert from landfills and measure them against the amount of non-recyclable materials in the products.
- Determine what percentage of the waste is actually reclaimed by recycling companies. (What is the percentage of recycled plastic that ultimately finds its way to the landfill due to contamination?)

Solar

The SSN provides electricity as a result of direct solar input. It is anticipated to eventually provide more cumulative power than it will take to manufacture its components. The SSN system components will be sourced based on short-term energy paybacks, e.g., Evergreen solar panels have an 18 month energy payback as compared to 3-5 years average for the other panels. Most solar PV panels have a 20-25 year guarantee that the module will provide minimum 80% rated output.

[31] Datschfski, Edwin, "Sustainable Products: Using Nature's Cyclic/Solar/Safe Protocol for Design, Manufacturing, and Procurement," *Biothinking International*, June 1999.

How to measure:

- Measure energy production used to manufacture all components against energy output of the solar PV panels to determine the time period until energy used to manufacture the panels is paid back.
- Benchmark the remaining life of system against energy consumption from other power generation sources

Safe

The SSN system will use, as available, components of minimal toxicity, e.g., using lead-free solder and chemical-free fluxes. Any toxic materials should be treated as "technical nutrients:" If the material will be used, every effort should be made to find a local recycling program for that product.

The greatest toxicity and safety concerns in the SSN design are posed by the use of AGM batteries (used at the Point Reyes Station prototype SSN) and "wet-cell" lead-acid batteries as the primary backup sources for solar PV systems. In addition to their potential to explode while charging, other safety concerns include the handling and disposal of materials found in these batteries (such as lead, lithium, and cadmium), as well as potential leakage of these materials onsite due to ruptures.

To help compare the direct environmental impacts of generator operation versus the direct environmental impacts of battery operation, the scorecards in Figure 8 were developed to provide a way to weigh various environmental factors.[32] Since every operation will be sited differently, use different battery and/or generator technologies, and conduct their maintenance differently (i.e. handling fuel and waste disposal), results will vary from installation to installation.

[32] *Hybrid Power Systems - Issues & Answers*, Sandia National Laboratories: Photovoltaic Research and Development, 2002: < http://photovoltaics.sandia.gov/docs/Hybook.html>.

Figure 8. Environmental Factor Scorecards: Generators and Batteries

Environmental Factor - Engine Generator					
Item	Weight (WF)	Low (1)	Average (3)	High (5)	Results
Rate the possibility of fuel spillage at the site.	8				
What is the potential damage to humans, animals, plants, or water if fuel spills?	8				
Rate the fire risk from stored fuel.	6				
Rate the possibility of damage from toxic emissions.	4				
Rate the problems that might be caused by operating noise.	4				
				Total Score	

Environmental Factor - Batteries					
Item	Weight (WF)	Low (1)	Average (3)	High (5)	Results
Rate the possibility of environmental damage from batteries	5				
Estimate the cost of disposing of used batteries.	3				
				Total Score	

As technologies become available, the system will be able to utilize less toxic materials. For instance, as fuel cells become cheaper and more reliable, they may be able to replace lead-acid batteries for energy storage. Lithium-ion batteries, such as those being developed for plug-in hybrids are also a possible replacement.

Key Advances Necessary for a Widely Dispersed *Solar Safety Net*

Advanced Inverters: SMA, a German company, has brought on to market a new 5000 watt inverter called the “Sunny Island” that is capable of “AC coupling,” a service equivalent to “islanding.” This inverter is capable of safely switching from grid-connected to battery charged service because it can send an artificial signal that simulates an active grid, which is then detected by standard solar inverters, allowing them to operate during blackout conditions. This is an important advance. Typical “grid-tied” solar arrays are designed to automatically shut off during blackouts in order to avoid back-feeding power to the grid. These battery-chargers/islanding inverters can be chained together and then engage in intelligent communication between each other as well as solar inverters. When integrated to the computer-linked Sunny Web Box, these processes can be managed completely on-site without the need for action by the host utility or the California Independent System Operator.

Better Batteries: The Sunny Island inverter can charge current technology such as deep cycle lead batteries. If money is no object, these batteries can be scaled up into larger and larger stacks. A very promising technology for near future appears to be lithium ion batteries. They are about one-tenth the weight of current battery technology and are far less toxic, but cost four to five times as much as a traditional battery. The technology needs to scale up, and the Chinese are leaders in this R&D, developing batteries capable of backing up 1 MW of electricity load. In contrast, the Tesla car that is being developed as a potential plug-in hybrid currently relies on 2,200 lithium laptop batteries.

Battery Isolation Technologies: The last piece of the puzzle when it comes to developing mass-scale Solar Safety Net systems relying upon "green" batteries is figuring out how to isolate each lithium ion battery cell. In current rigging arrangements, when one battery dies, it creates a "hot spot" in the battery array, causing it to fail. If the SSN is to achieve its reliability goals with lithium ion batteries during emergency power outages, this dilemma – which appears to be the largest current technical obstacle – needs to be resolved. That said, current battery systems are a completely functional cost-effective solution that can be employed to implement first generation SSN systems today.

The SSN will meet the safety standards of utility companies, and its components will meet, at a minimum, UL compliance standards. Additional safety measures include location of equipment and proper installation practices.

Because the SSN uses renewable energy, it will produce virtually no harmful pollutants when generating power.

How to measure:

- Benchmark pollutants generated by other power sources against the SSN.
- Measure the amount of hazardous materials in the SSN's components. Determine the probability of improper disposal of these materials.
- Evaluate prime locations for SSN components (i.e. away from heavily-trafficked areas, enclosed in secure structures).

Efficient

While fossil fuels currently provide more concentrated energy sources than photovoltaics, and thus are technically more efficient, the SSN is designed to use energy more efficiently at the point of distribution. It is anticipated that as more sophisticated controls and built-in algorithms become available, this will increase load management capabilities and overall efficiencies.

Providing additional power during peak times and managing electricity peaks through demand response systems will also reduce the use of existing peaker plants, which are generally older, are less frequently used, and because they are only run for short periods of time, are generally not built to be as efficient as base load power plants.[33]

How to measure:

- Use conventional peak demand load-shedding models to benchmark efficiency metrics against the SSN's system of distributed generation and load management.
- Compare efficiencies of the SSN against comparable renewable energy sources.
- Measure the efficiency of the SSN system using varying levels of load management devices.

Social

The SSN uses distributed renewable energy resources and encourages the proliferation of renewable power generation at the local level. As a mechanism for energy independence, this ultimately empowers consumers and leads to the democratization of the grid. It also leads to more affordable electricity, fewer fossil and nuclear-fired power plants and a healthier environment.

The concept of neighborhoods "owning their own electrons" will also foster a stronger sense of community – particularly if that community is also a part of the emergency response system and/or the SSN's ongoing maintenance plan. The implementation of an SSN also fosters both user advocacy and outreach: existing and potential consumers will be more educated about the benefits of renewable energy.

In an ideal scenario, the SSN system components will be sourced domestically, as available. The actual construction of the SSN would also boost the local economy. In addition to increasing local revenues in the construction sector, SSN projects could also be used in conjunction with "green collar" job training programs. As a result, members of the community in need of trade skills would be able to become more financially independent and contribute to renewable energy in their own communities.

How to measure:

- Determine the annual rate at which increased demand for skilled installers and maintainers leads to increased employment and possibly a lower demand for social services – especially if implemented in conjunction with a "green collar" job training program.
- Determine decreases in social problems as a result of a "green collar" job training program.
- Measure the qualitative factors of using renewable energy and buying and sourcing labor locally, with as few toxic components as possible. Factors could include: Increased sense of community, security during a blackout, and "doing the right thing."

[33] "Peaking Power Plant, "wikipedia.org. June 7, 2008: <http://en.wikipedia.org/wiki/Peaking_power_plant>.

Conclusion

The era of the highly centralized systems such as our current electricity grid may be coming to an end. There is a shift in our culture to an emphasis on local responsibility for the food and energy systems that we depend on for vital needs. Deregulation of power systems, communication systems and other centralized systems continues at a rapid pace. The political preference for smaller government is now in its fifth decade.

There is no reason for neighborhoods to be provided solely with power shipped from a great distance, incurring high line-losses, when there is energy landing directly on the rooftop of each electricity customer. When there are emergency breakdowns, who can you depend on besides your very own neighbors? The growing specter of disasters and emergencies due to increasingly extreme weather, earthquakes and sabotage lead us to think more clearly about what resources are available in our local regions, as the supply lines from distant countries, farms and power plants become less secure.

If FEMA were to fund SSN systems throughout the country as part of its Disaster Preparation and Mitigation Program, it would be making its own job much easier during those emergencies that are truly unpredictable. It would be enabling all of the citizenry in the areas surrounding any true disaster to become part of the solution. When a citizen body has made – house by house, neighborhood by neighborhood, and community institution to community institution – the preparations necessary to prevent the loss of essential support systems, it has prepared its mind and its capabilities to be of significant help to those rendered helpless by a complete collapse in a nearby region.

Based on interviews and evaluation of various design concepts, the SSN appears to be technically feasible, yet requires significant coordination, cooperation, and investment by numerous stakeholders. According to Tom Willard, Principal at Sustainergy Systems, "There are a number of initiatives currently underway and private players working on the required enabling technologies. What this means is that a micro-grid for a SSN that is well-integrated with the existing electrical utility grid is well within the realm of possibility in the next decade, if not considerably sooner."

The SSN can provide custom-designed solar PV systems with the ability to distribute power loads across multiple functions of a building while capturing demand reduction onsite. The SSN concept represents energy independence, efficiency, and community if developed at the neighborhood level or at a large disaster relief site (as is the case in Point Reyes Station.) Ultimately, if combined with smart micro-grid and demand response technologies, the SSN could represent the highest level in energy emergency security. Through its use of integrated solar PV technology and environmental responsibility in components sourcing, the SSN also offers the most environmentally sustainable solution to the challenge of short and long-term emergencies. If implemented in communities of need, especially by those residents in need of job training, the SSN could also be a social solution in those communities, too.

The SSN would most likely be considered a public good, and therefore qualify for public financing such as use of the property tax system or even tax-exempt bond financing. The SSN might also qualify for FEMA funding by being incorporated into a larger county/regional projects based on renewable resources and scenario planning for emergency, disaster, and catastrophes. This would make an SSN system cost competitive without creating harmful emissions or potential adverse health affects and maintenance risks associated with conventional emergency generator backup systems.

Appendix B: Summary of IEEE Standard P1547 (SCC21) as it relates to Inverter Disconnects and Islanding

The Institute of Electrical and Electronics Engineers (IEEE) provides minimum testing, operation, communications, and monitoring standards for equipment (i.e. inverters) which are a part of grid-tied distributed resource (DR) systems. These standards are part of P1547, the *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*.

Among other things, the standard stipulates that no phase of a Distributed Resource (DR) such as a PV system shall energize the local portion of the utility grid — the Area Electric Power System (Area EPS) — when the Area EPS is either de-energized or experiences abnormal fluctuations either in voltage (Table 1) or frequency (Table 2). Once de-energized, no reconnection to the Area EPS will take place until the voltage of the Area EPS rises to 50 or drops to 88, or until the frequency drops to 60.5 or rises to 59.3 Hz. This may take as long as five minutes after voltage and frequency have been restored.[34]

Table 1—Interconnection system response to abnormal voltages

Voltage range (% of base voltage[a])	Clearing time(s)[b]
V< 50	0.16
50 ≤ V< 88	2.00
110 < V < 120	1.00
V ≥ 120	0.16

[a]Base voltages are the nominal system voltages stated in ANSI C84.1-1995, Table 1.
[b]DR ≤ 30 kW, maximum clearing times; DR > 30kW, default clearing times.

Table 2—Interconnection system response to abnormal frequencies

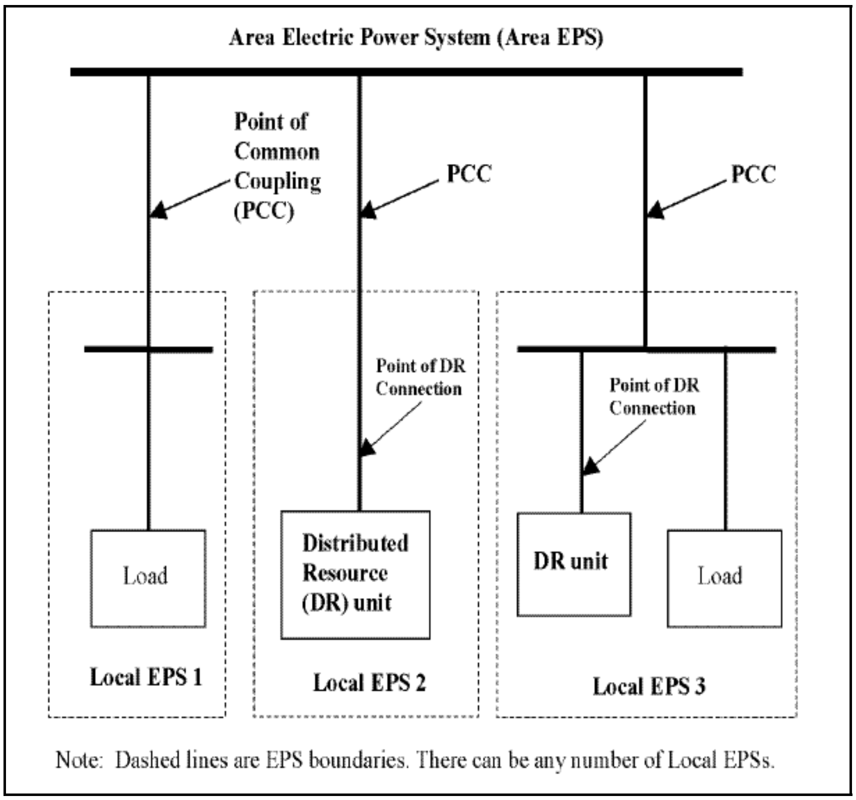
DR size	Frequency range (Hz)	Clearing time(s)[a]
≤ 30 kW	> 60.5	0.16
	< 59.3	0.16
> 30 kW	> 60.5	0.16
	< {59.8 – 57.0} (adjustable set point)	Adjustable 0.16 to 300
	< 57.0	0.16

[a]DR ≤ 30 kW, maximum clearing times; DR > 30 kW, default clearing times.

[34] "P154: *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*. Institute of Electrical and Electronics Engineers Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage: New York, NY. July 28, 2003, p. 9.

In addition to requirements for grid abnormalities or grid failure, P1547 also sets disconnect guidelines for "islanding." An "island" has been defined in the standard as a condition resulting when an Area EPS has been electrically separated from the greater Area EPS (as a result of a blackout, for instance). But because a power-generating DR unit such as a solar PV system is energizing a Local EPS, which is connected to it through a Point of Common Coupling (PCC), that portion of an Area EPS remains energized *solely* by the Local EPS.[35] Table 3 illustrates the relationship between the DR Unit, three Local EPSs, the Area EPS, and the PCC.

Figure 9.



In the event of an unintentional island, the DR interconnection system will detect the island and cease to energize the Area EPS within two seconds of the formation of an island.[36] In the case of the SSN, this de-energizing would be done by the inverter in two ways: using passive methods which would react to the detection of harmonics or phase differences, or to a detected change in voltage frequency from the EPS; or though active methods, in which the inverter introduces a deliberate modification in frequency, voltage or impedance, and this modification would only be detected by the inverter when the normal frequency, voltage, or impedance levels of the EPS is *not* present.[37]

[35] *Ibid*. p. 4.
[36] *Ibid*. p.10.
[37] Bower, Ward, and Ropp, Michael, *Evaluation of Islanding Detection Methods for Utility-Interactive Inverters in Photovoltaic Systems*, .Sandia National Laboratories: Albuquerque, NM and Livermore, CA, November 2002.

Standards for intentional islanding, or the formation of micro-grids, are currently under consideration for future revisions of P1547.[38]

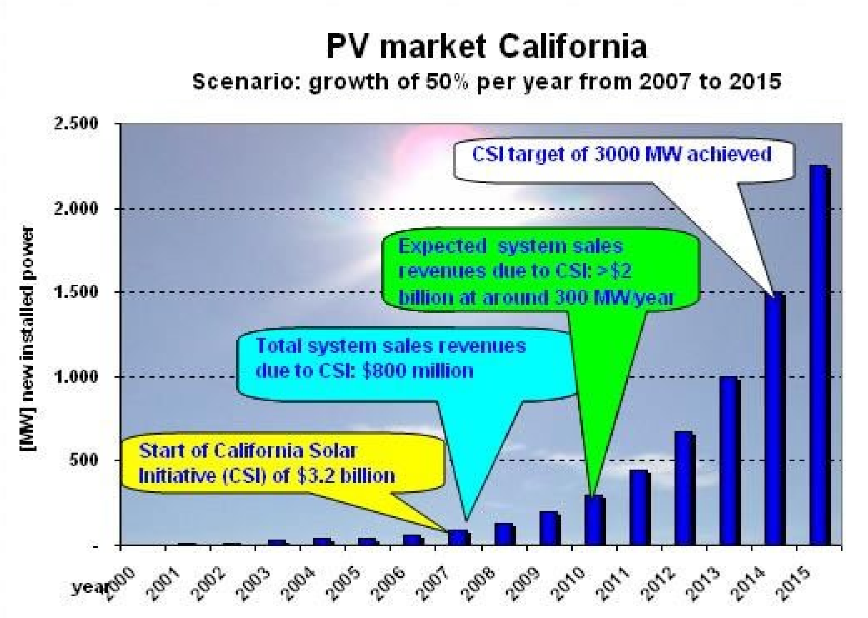
For manual disconnects, the standard requires that a lockable, visible-break isolation device be located between the Area EPS and the DR unit. DR units (or a collection of DR units) of 250 kVA or more at a single PCC should have a way to monitor connection status, real power output, reactive power output, and voltage at the point of the DR connection.[39]

[38] "P154: *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*. Institute of Electrical and Electronics Engineers Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage, New York, NY, July 28, 2003, p. 10.

[39] *Ibid*. p. 7.

Appendix C: Profitability Analysis

Over the past three years the U.S. solar energy market has witnessed dramatic increases in solar power revenues, which also indicates that numerous incentives and production factors will boost the industry to triple its growth through 2012. Some research estimates this growth exceeding



$32 billion by that year.[40] Although growth is anticipated to accelerate in the future, the industry's success could also hinge on advances in solar power technology, increasing private-sector solar investment and growing public-sector support. This is particularly true now that the U.S. and local governments are creating incentive programs that support installation of solar energy systems.

The California solar market has shown a growth rate of approximately 40%. With the new California Solar Initiative (CSI) program started in 2007, the California solar market will continue to grow into the future. A conservative scenario of 50% annual growth would result in total sales revenues of more than $800 million for solar systems in 2007, increasing to as much as $2 billion by 2010.[41]

Although the solar energy market is still in the beginning stages of development, it is clear that solar power generation and backup systems provide a new type of revenue stream to help support the installation of commercial-scale and distributed solar facilities, while at the same time raising consumer awareness of the benefits of renewable energy during emergencies.

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[40] "Photovoltaics market to top $32.3 billion by 2012, says BCC Research," pv-tech.org. January 3, 2008.: < http://www.pv-tech.org/fab_and_facilities/article/photovoltaics_market_to_top_323_billion_by_2012_says_bcc_research>.

[41] "Solar market boom in California; Silicon Valley centre of new PV industry?" www.solarplaza.com. May 8, 2007: <http://www.solarplaza.com/content/pagina/SiliconValleyArticle/45026>.

The following service development cost table (Table 4) represents the profitability of the SSN consulting service for investors during the first 10 years. For simplicity, net income in this table is based solely on the installation costs of the SSN, and uses the Dance Palace Community Center's 10 kW system as the model size. The model assumes the following:

- $42,287 for equipment (post-rebate), based on the $45,000 equipment purchase at retail prices by the Dance Palace community center. For the purposes of this analysis, the retail price was then discounted to wholesale costs by a standard 10%.
- Labor cost per square foot of $5.40. This assumption was based on averaging the maximum $7.00 cost per square foot and the minimum $3.87 per square foot on a 10 kW system (which would require an estimated 331 square feet of 190-watt photovoltaic panels).
- The sales price per unit reflects a 10% markup on retail equipment costs and labor.
- A somewhat conservative 45% annual growth rate in the sales volume (the projected growth rate for the photovoltaic industry is 50%)
- A somewhat aggressive 2.5% quarterly increase in promotion, direct sales, and service costs.
- A cost of capital at 9.6% (using the CAPM model: An average 2% rate on 90-day treasury bills plus a 7.6% market premium)

Given these assumptions, cash flows for just the installation component of the SSN should see a positive net present value by year six. Note that this model does not factor consulting fees for design or other integrative or facilitative services into the sales revenue.

Table 4. Service Development Table:

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Development Cost:	-$200,000									
Ramp-up Costs	-$50,000	-$50,000								
Marketing & Support Costs:										
Launch Costs		-$7,500	-$2,500							
Promotion Costs		-$7,500	-$10,000	-$10,641	-$11,745	-$12,965	-$14,311	-$15,796	-$17,436	-$19,246
Direct Sales Costs		-$7,500	-$10,000	-$10,641	-$11,745	-$12,965	-$14,311	-$15,796	-$17,436	-$19,246
Service Costs		-$7,500	-$10,000	-$10,641	-$11,745	-$12,965	-$14,311	-$15,796	-$17,436	-$19,246
Production Costs:		-$422,870	-$592,018	-$888,027	-$1,268,610	-$1,860,628	-$2,706,368	-$3,890,404	-$5,666,458	-$8,203,678
Production Volume		10	14	21	30	44	64	92	134	194
Unit Production Cost*		-$42,287	-$42,287	-$42,287	-$42,287	-$42,287	-$42,287	-$42,287	-$42,287	-$42,287
Sales Revenue:		$465,157	$651,220	$976,830	$1,395,471	$2,046,691	$2,977,005	$4,279,444	$6,233,104	$9,024,046
Sales volume (assumes 45% growth/quarter)		10	14	21	30	44	64	92	134	194
Unit Price		$46,516	$46,516	$46,516	$46,516	$46,516	$46,516	$46,516	$46,516	$46,516
Period Cash Flow	-250,000	-37,713	26,702	56,880	91,625	147,168	227,705	341,651	514,337	762,629
PV Year 1, rate of return = 9.6%	-$250,000	-$36,829	$25,465	$52,974	$83,332	$130,712	$197,502	$289,390	$425,450	$616,047
Project NPV	-$250,000	-$286,829	-$261,364	-$208,390	-$125,058	$5,653	$203,156	$492,546	$917,995	$1,534,042

* Includes 1) estimated retail parts cost of $45,000, and 2) labor on an average 10 kW system (22 190-watt panels) at an average $5.40 per square foot (http://www.energy.ca.gov/pier/renewable/projects/fact_sheets/XANTREX.pdf)

Part III:

COMMUNITY CHOICE AGGREGATION AND EMERGING SMART SOLAR MICRO-GRIDS

Pathfinder Communications
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June 2008

A report funded by the
Marin Community Foundation

Introduction: Marin Clean Energy

The Community Choice Aggregation (CCA) law allows local governments to choose a power supply portfolio for its constituents while allowing the host distribution utility to continue to provide distribution, billing and repair services. This law offers many potential advantages to communities seeking to control their own energy destinies. Since the current business plan of the CCA being proposed for Marin County – known as "Marin Clean Energy" (MCE) -- proposes a power portfolio that moves toward the ultimate goal of 100% renewable resources, creative thinking about ways to aggregate supply and demand are more possible. Among the potential benefits of a CCA are the following:

- *Affordable Renewable Energy* – Under this program, homes and businesses can enjoy the benefits of non-polluting renewable energy resources at the most affordable price. Communities can determine how their electricity is generated – from clean and renewable resources rather than polluting and finite fossil fuels.

- *Greater Price Stability* – California's growing demand for electricity is expected to be met by an increasing dependence upon natural gas-fired power plants. California already imports about 84 percent of its natural gas from other regions. Renewable energy sources have no fuel cost and are not subject to the price volatility inherent to natural gas markets.

- *Promote Local Clean Distributed Generation* - Any local government can create its own rates and incentives with a CCA to promote a greater reliance upon local "distributed generation" facilities such as solar PV panels, small on-site wind turbines, and cogeneration facilities or fuel cells that may help businesses be more efficient with their use of fossil fuel supplies.

- *Local Accountability* – Unlike investor-owned utilities, local governments are accountable to their citizens through locally elected officials whose tenure is predicated on performance. The decisions of a local power authority could be more transparent and responsive to the desires of the community than the actions of a private utility regulated by the CPUC in San Francisco.

- *Public Financing of Generation* – Local governments have a substantial financial advantage over investor-owned utilities when investing in new power supply. They can access lower cost tax-exempt financing and do not have to pay income tax or any profits to shareholders.

The energy business is full of risk, among them the volatility of natural gas prices, the dominant supply for PG&E. At present, over half of new power plants are being developed by non-utility providers. A CCA can tap into this vibrant market for a variety of energy services, including short-term trading and development of new power plants. Ironically, a CCA also allows Marin County to align with corporations even larger than PG&E when it comes to power generation assets and daily energy trade volume: financial institutions such as Citi, Morgan Stanley and Goldman Sachs. Other options include municipal utilities such as the SMUD or the Northern California Power Agency. The CCA also offers a local government the opportunity to tap smaller, local sources of generation, projects that might not be appealing to a large investor-owned utility seeking large increments of power to meet its entire customer base. For the sake of comparison, Marin County's 240 MW of load compares to PG&E's 20,000 MW.

Studies on how best to build organizations to foster innovation have identified a class of technologies that have different characteristics than traditional technologies and therefore help introduce new ideas into an already established market. They often do fit easily into the existing paradigm. These technologies have been deemed "radical" or "disruptive." In the energy arena, these technologies include distributed resources such as solar PV, small wind, hydrogen fuel cells and a variety of energy efficiency devices.

Radical and *disruptive* technologies (see Figure 10) trigger a need for organizational changes. These sorts of changes often challenge existing or traditional organizations, such as today's electric utilities. The electric utility industry is changing and new structures are evolving – such as the CCA -- that can more effectively maximize the unique characteristics and value of these technologies. New models of development – i.e. the Community Solar (CS) and Solar Safety Net (SNN) – are also evidence of these game-changing technologies.

Figure 10.

Marin County's Unique Energy Profile

The CCA program offers an opportunity to take advantage of several unique features of Marin County energy consumption profile. For example, Marin County's electricity demand peaks in the winter, the opposite of most of the state. When Marin County peaks in the winter, available resources are often low-cost. This theoretically means Marin County could generate excess renewable energy at times when the rest of the state's demand for energy is peaking. Under the proposed market re-design by the California Independent System Operator (CAISO) – which manages transmission services for the majority of the state electricity sales – Marin County may be able to meet most of its demand during these winter peaks with least cost energy supplies.

Another major factor that enables Marin County to take a more aggressive approach to renewable energy is that, unlike most local governments, a majority of its constituents are residential customers, whose electricity bills are relatively small. What this means is that the "above market" costs associated with the proposed 100 percent renewable energy portfolio translate into relatively small rate increases (i.e. $8 to $10 per month.) Furthermore, it is a slow growth region. Unlike large investor-owned utilities such as PG&E, which claim that lack of transmission capacity hinders its efforts to add new renewable energy resources to its supply mix, Marin County can easily access enough renewable supply to satisfy its demand.

Because it is a slow growth county, no new transmission upgrades are necessary to meet MCE's proposed goal of ultimately providing an all-renewable resource mix. The existing transmission infrastructure can access adequate supply to serve Marin County's 240 MW load. Therefore, a CCA in Marin County could help meet a significant share of new electricity demand with indigenous resources that not only include solar PV, but small wind, micro-hydro and biogas. For example, the Buck Institute in Novato is interested in self-generating. The CCA could help develop an anaerobic digester there, where the County's waste could be sent to produce clean on-site power. These sorts of projects are often not cost-effective for a large investor-owned utility, but would be of great interest to local governments creating a CCA.

One of the main obstacles to further innovation on energy matters at the local level is that Marin County lacks enterprise agencies like those operating at other local governments. Such agencies can provide retail water, sanitary or power services that can generate revenue through small ongoing fees. Local enterprise agencies can help support staff and provide the fiscal resources to explore new opportunities and innovate. One of the main advantages for a local government creating a CCA is providing a sustainable source of funding for local energy programs that benefit that entire region. More specifically, the CCA could authorize a "public goods" surcharge similar to that imposed by the CPUC on investor-owned utilities, which could then provide the fiscal means to fund local distributed generation projects. The CCA may also be able to own and then lease solar PV systems much like SMUD's original community solar development program.

The CCA, Community Solar and the Solar Safety Net

What could a CCA specifically do to support CS projects? The proposed Joint Power Agency to be created to implement the CCA in Marin County – Marin Clean Energy --would be able to provide partial net metering incentives and credits. Because a CCA is responsible for the *generation* component of electrical service, the CCA could credit the generation portion of the net metering service as a CS incentive. Since generation comprises roughly half of one's total electricity service costs, a CCA could provide "virtual" or "off-site" net metering credits, but the credits would only cover half of the total costs (since the transmission and distribution portion of the bill and/or credit is still controlled by and paid for by the host investor-owned utility.)

The CPUC has ruled that all members of a CCA are still eligible for California Solar Initiative (CSI) rebates since these rebates are available to all distribution customers of any investor-owned utilities, regardless of source of generation service. If PG&E were willing partner, CS projects could be fully credited for the transmission and distribution portion of one's net metering arrangement for a CS project on a voluntary basis. Most likely, new legislation might be required to mandate distribution utilities to provide the transmission and distribution net metering credits with CS projects.

One example of how the CCA may be able to augment state policy is this legislative session's AB 1920, authored by Jared Huffman (D-San Rafael,) which offers payments to solar PV systems that can sell excess generation beyond annual load requirements. The rate being offered under AB 1920 may not be attractive enough to most solar PV system owners. A CCA would not be able to offer a full retail rate, but has the capability to provide a greater incentive for local solar PV excess generation than the host distribution utility (i.e. PG&E).

What could a CCA do for the SSN? The answer to that question is less clear and more complicated. The changes in utility practice and codes required to implement a Solar Safety Net are developed by institutions such as IEEE or governed at state and federal levels of government. While CS may challenge long-standing policies embedded in CPUC Code 218B2, the SSN bumps up against even more formidable rule changes as well as cultural barriers. In fact, the Sandia National Laboratory test for inverters required for grid-connected solar PV arrays currently includes an anti-islanding design requirement. Many former utility managers interviewed for this project agreed this barrier to certification highlights the profound impact the culture of utility engineers has on emerging technologies that shift control of the distribution system away from centralized command-and-control.

Some of the challenge comes down to simple changes in language Utilities engineers often become alarmed when they hear the term "islanding," but use the term "micro-grid" and they seem to be OK. Other examples include the term "meter" – which infers revenue collection. A better term in the brave new world of choice and local reliance might be "customer information gateways." Yet another term is "dispatchable," which means one thing to utility managers: a switch can be turned on and off. That definition doesn't quite apply to intermittent renewable distributed generation systems or smart demand response load shifting technologies that can be managed autonomously at the point of consumption. One possibility for another better term is "controllable" resources.

In terms of the SSN, the safety issue is the major stumbling block and a vestige of concerns shaped by traditional technologies. In fact, the standard operating procedure is for the line worker to always check the line before proceeding on any work, but the severe safety issue surrounding electrocution are not easily forgotten. The real fear is that a solar PV system comes back on once the line has been checked by the line worker. Ironically enough, fire codes may also be a challenge. Fire departments have expressed concerns about solar PV on rooftops in general, and how to work around them in the event of a fire. It should be noted, nevertheless, that safety concerns about electrocution when hybrid cars are involved in accidents have not slowed down the introduction of that cleaner technology into the transportation sector.

A looming key issue impacting future innovation such as the SSN is PG&E's planned upgrades to the transmission infrastructure, which could represent an investment of some $2.3 billion in total expenditures (http://docs.cpuc.ca.gov/efile/A/82845.pdf). This filing at the CPUC – A.08-05-023 – includes $987 million in new revenue requirements from ratepayer funds. Depending upon the design criteria, allowing utilities to rate-based upgrades to a smarter grid could foster a greater reliance upon distributed generation and demand response technologies. But it could also strangle efforts to build more autonomy into the distribution system. One has to be careful that the utility's approach to upgrading its delivery system does not preclude creativity at the local distribution level and "disruptive technologies" and new models of energy service such as micro-grids like the SSN. And that's why "open source" architecture – such as that employed with current telecommunications and Internet services -- is so important. From now on, upgrades to the grid must take into account the world's rapid shift toward a post-carbon energy economy and a world less vulnerable to terrorists and sabotage.

Linking to Smart Micro-Grids

A Marin County “smart grid” pilot project funded by the federal Department of Energy (DOE) offers an opportunity to think through some of these “open source” architecture issues. The DOE-Marin Integrated Renewables Community Project is a $1.6 million dollar research effort that will span three years. It is designed to integrate and monitor up to ten solar PV projects located in a contiguous part of the PG&E grid in Marin County. The Marin sites will be identified in late 2008 or early 2009. The requirements at the local level in Marin County will be analyzed, as will the interoperability with PG&E’s SCADA systems (which insure proper voltage). Both of these tests will first be simulated at the National Renewable Energy Laboratory (NREL) Distributed Energy Resources Test Site in Boulder, Colorado before being deployed at solar PV facilities in Marin County. The concept of this smart grid pilot is to field test software technologies for optimizing the use of solar PV and demand response at the local micro-grid level based on local contingencies, outages, and requirements. This local approach pilot project contrasts with a system wide approach by PG&E or the CAISO that relies upon a centralized computer. GridAgents, a division of Infotility, Inc. located in Boulder, Colorado, is managing this project.

(The CAISO has expressed great interest in this pilot project. As the manager of transmission resources across the state, it believes that investor-owned utilities are not doing enough to implement demand response technologies. It, too, is beginning to look for ways to reduce peak demand at the residential level.)

Should a solar PV system store its energy in batteries or release it for consumption? New technologies offer the intelligence to make these sorts of decisions at the local level. Today, utilities are blind below the substation level. That means they have no information or control over these micro-power solar PV resources or localized demand response. With the smart micro-grid being tested in this Marin County pilot project, one can filter data locally, and act reasonably quickly. This is important. And while it is easy to collect lots of metered or sensor data today, the challenge is how one can make sense of it. Figuring out how to tie the solar PV data and other demand response resource data together to best support a local micro-grid is the over-arching purpose of this project. Supported by a CCA, such efforts at local control through software innovations could greatly expand the availability of a SSN network.

Ultimately, individual homes will have the capability to manage all appliances and related electrical equipment through a private energy management web portal. This would enable solar PV system owners to maximize efficiency (and profit) when selling back to the grid and to then purchase utility power when the price is low. The intelligence embedded in such a system could also be employed to create emergency micro-grids – SSNs – that could rely upon solar energy stored in batteries to power appliances at night or during emergencies.

Smart grid innovators show that the SSN is quite feasible at the single household level. The Dance Palace Community Center in Point Reyes Station is a pilot project regarding large disaster relief structures preparing for future emergencies today. When one expands these models out to entire neighborhoods – as contemplated in the analysis of the SSN in Part II of this report – one merges the SSN with the concept of CS smart grid. This technological advance also taps into the natural desire for humanity to share vital resources during times of emergency

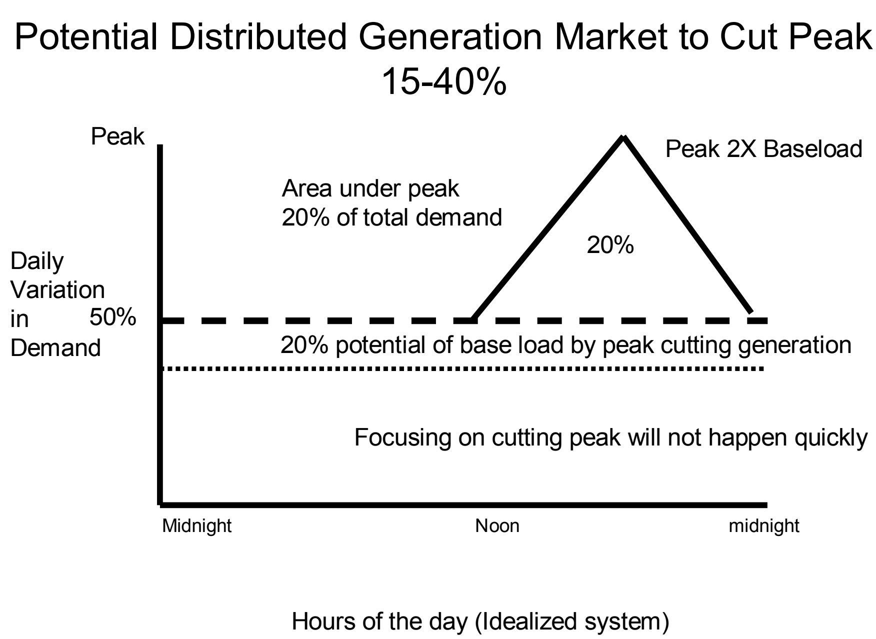
Once the new IEEE standards provide safety and reliability solutions for distributed resource islands, the last remaining hurdle to integrated "Community Solar/Solar Safety Net" systems is storage. Whether that storage comes in the form of better batteries, or flywheels, compressed air or micro-hydro storage ponds, the ability to store and strategically release renewable energy supplies in an intelligent manner at the local level is the vision that should guide future investigations of these critically important matters.

Conclusion

What the CCA, CS and SSN all share in common is their emphasis on community. The evolution of our energy infrastructure has allowed humanity to become isolated, without regard to needs of neighbors, the regional ecosystem and the cycles of weather. Shifting to an energy system tailored to the distinct needs and interests of the local citizenry transforms energy from being the enemy and cause of so many environmental, economic and social problems, to an engine of sustainability that can drive society forward toward a paradigm of synergy and collaboration.

Moving in a direction of local two-way energy flows – where every consumer also has the option to become a producer (much like the Internet) -- requires an open market and choice. New organizational structures such as the CCA, and new models of solar energy development such as CS and SSN, move us closer to this reality. It is possible to meet significant portions of Marin County's total demand from distributed generation sources such as solar PV (see Figure 11 below.) But a smart grid will be necessary. The beauty of the SSN is that the renewable energy systems can continue to power vital needs when the grid fails. It can also respond to the need to reduce carbon emissions and large centralized power plants that represent terrorist targets.

Figure 11.

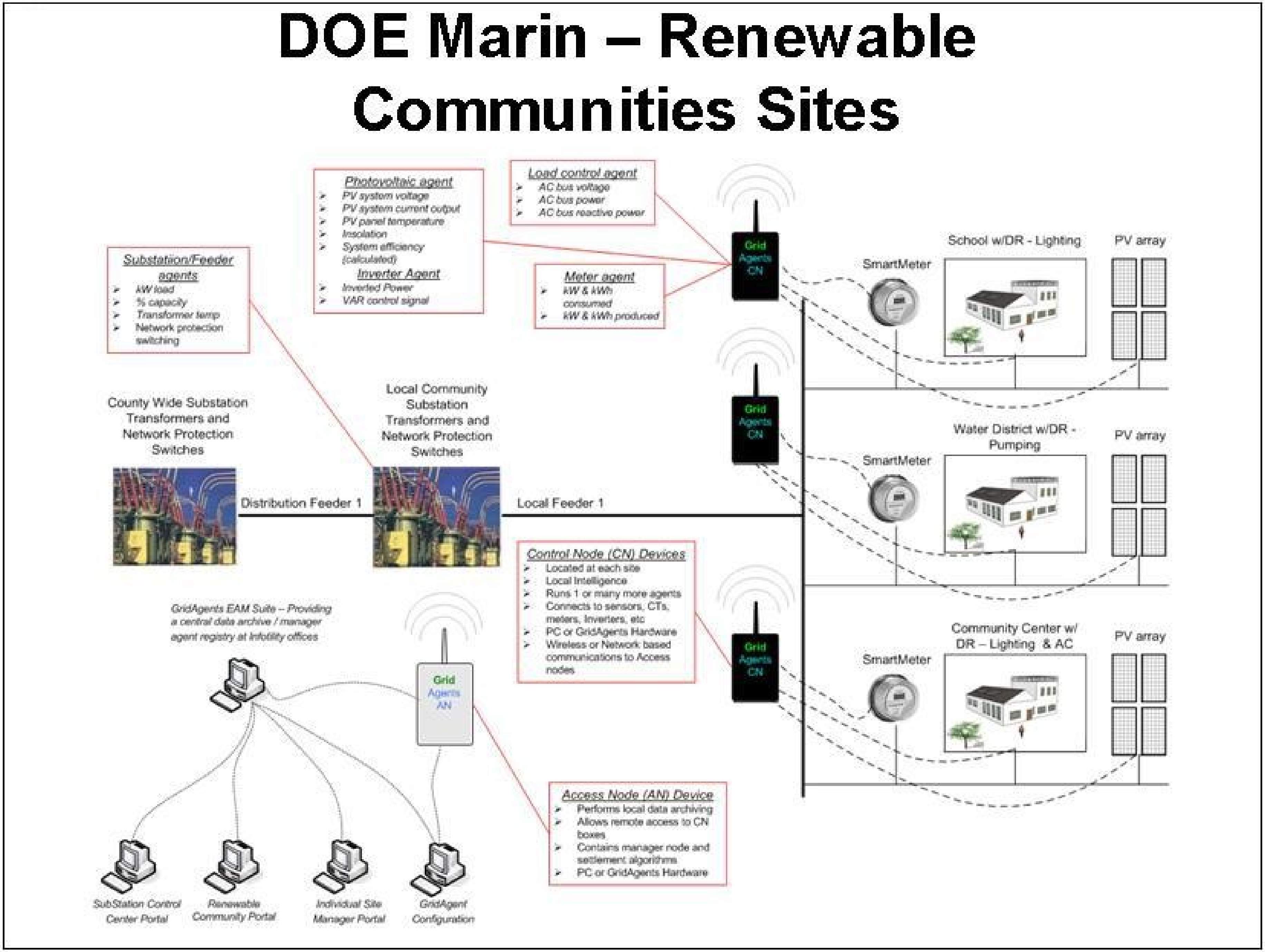


Most electrical utility systems have a peak demand for power that is approximately twice the size as the base load demand that occurs during the day. Figure 11 is an idealized system demand curve. The demand under the peak – the triangle -- is the most expensive to generate and the generation system must be sized to handle that peak. The area under peak represents approximately 20% of the total demand. Greater asset utilization occurs if that peak is not allowed to propagate and then be handled by power plants hundreds of miles away. The peak should be reduced as close as possible to where it is produced in the first place. Technologies, such as solar PV, are now evolving and can accomplish this goal. The beauty of such a system is that distributed generators can continue to generate even when not on peak, reducing the need for large central power plants by 20%.

It is important to note that over the past century, power supply has been governed by the economics attached to the scale of *construction*. As society moves toward a new paradigm more focused on distributed resources such as solar PV and demand response, it is the economics of the scale of *manufacturing* that becomes the prime gatekeeper for new technologies. As these technologies move from boutique to mainstream options, costs go down, and they become more affordable. The evolution of telecommunications and computers are good analogies.

All told, these distributed power sources could provide approximately 40% of total demand in Marin County and elsewhere. But it will take time to evolve to such a distributed and democratic energy system. Marin County can serve as a testing ground of how to move toward such a system in a sustained and orderly manner, gradually displacing renewable power purchases from sources outside the county's borders with more decentralized solar PV and other local renewable energy sources located nearby. In the end, the only real barriers to these new models of solar energy development are the lack of creative thinking and the formidable status quo economic relationships.

Appendix D:


DOE Marin – Renewable Communities Sites
Photovoltaic agent
PV system voltage
PV system current output
PV panel temperature
Insolation
System efficiency (calculated)
Inverter Agent
Inverted Power
VAR control signal
Load control agent
AC bus voltage
AC bus power
AC bus reactive power
Meter agent
kW & kWh consumed
kW & kWh produced
Substatiion/Feeder agents
kW load
% capacity
Transformer temp
Network protection switching
Grid Agents CN
School w/DR - Lighting
PV array
SmartMeter
County Wide Substation Transformers and Network Protection Switches
Local Community Substation Transformers and Network Protection Switches
Distribution Feeder 1
Local Feeder 1
Water District w/DR - Pumping
PV array
SmartMeter
Control Node (CN) Devices
Located at each site
Local Intelligence
Runs 1 or many more agents
Connects to sensors, CTs, meters, Inverters, etc
PC or GridAgents Hardware
Wireless or Network based communications to Access nodes
GridAgents EAM Suite – Providing a central data archive / manager agent registry at Infotility offices
Grid Agents AN
Community Center w/ DR – Lighting & AC
PV array
SmartMeter
Access Node (AN) Device
Performs local data archiving
Allows remote access to CN boxes
Contains manager node and settlement algorithms
PC or GridAgents Hardware
SubStation Control Center Portal
Renewable Community Portal
Individual Site Manager Portal
GridAgent Configuration